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ON THE STRENGTH OF AMERICAN TIMBER.*

[An Experimental Investigation made in the Mechanical Laboratory of the Stevens Institute of Technology.]

By Prof. R. H. THURSTON.

INTRODUCTORY.—One of the earliest investigations planned by the writer when organizing the Mechanical Laboratory of the Stevens Institute of Technology was that here described. Nearly all our knowledge of the strength of timber was derived from foreign sources and was of limited extent, and authorities were somewhat conflicting in statement.† It was evident that more work in that department of research was required, and that experiments on the strength of American woods were demanded not only by engineers and architects in the United States, but by members of the profession in Europe, where some American timber—especially our soft pines—is used.

The experiments here described are too few in number, and cover too limited a portion of this field to claim attention as really authori-

* A paper read at the Saratoga meeting of the American Association for Advancement of Science, August, 1879.

† Compare Barlow and Tredgold with Laslett. Barlow on the Strength and Stress of Timber, London, 1826; Tredgold's Elementary Principles of Carpentry, London, 1870. Laslett on Timber and Timber Trees, London, 1875.

tative and satisfactorily complete; they will, however, have some value, and may be taken as an initial portion of a complete study of American woods which, it is hoped, may hereafter be made.

The writer desires to express his obligations to the Secretary of the Navy, to the Chief of the Naval Bureau of Construction of the Navy Department and to the Naval Constructor of the Brooklyn Navy Yard for a kindly interest taken by them in the work, and particularly for the important assistance rendered by them in carrying it out.

It seemed eminently desirable that the woods examined and experimented upon should be of the kinds used most generally in construction; that the specimens should be of sound, good stock, and that the test-pieces should be carefully and accurately made to standard size and shape. As the best means of securing these desiderata, the Secretary of the Navy and the Chief of Bureau were requested to furnish test-pieces of the form and size standard in the Mechanical Laboratory of the Stevens Institute of Technology. The favor was cheerfully granted, and the Naval Constructor, on receipt of orders from the Navy Department, prepared the required specimens at the Brooklyn Navy Yard, at the earliest practicable date, taking a personal interest in securing the desired quality of material and accuracy of workmanship. The samples thus furnished may be regarded as well representing those American woods which are here treated of.

The samples furnished were of white and yellow (Georgia) pine, locust, black walnut, white ash, white oak and of live oak.

The characteristics of good pine timber are the following:

It has a close grain and its slow growth should be evidenced by the thinness of the annual rings, which should not exceed a tenth of an inch. The trunk, and consequently its rings, should be symmetrical.

The best timber is charged with resin, which preserves it from decay, and gives it strength and elasticity; its presence is indicated by strong odor. The color of the wood should be a clear tint of yellow and red, alternating, and the texture as well as the colors should be very uniform.

The working of the timber gives a reliable indication of its quality. It should offer considerable resistance to splitting along the grain, it should be strong and free from wooliness, and the cut of the saw, and of the plane or chisel, should leave smooth surfaces. The shavings and chips should be strong and elastic, and the former capable of being twisted about the finger without breaking.

White pine (*Pinus strobus*) is a native of North America, and takes its name from the color of its wood. It grows in all kinds of soil. The best timber is found in cool, damp situations, in the forests of the Northern United States and Canada, between the forty-third and forty-seventh parallels of north latitude. It really flourishes well as far south as Virginia. It grows to great size, reaching a height of upwards of 200 feet, with a diameter of 10 feet at the height of a man's shoulder from the ground. It is the tallest tree in our forests. It sometimes reaches the age of 350 years. Single logs have been cut 36 inches square and 60 feet long.

Its wood is yellowish-white in color, light in weight, rather soft, free from knots, straight grained, and is very easily cut. It is durable only in dry air. It contains very little resin; its leaves are very slender; its cones are very nearly cylindrical and 4 or 5 inches long. Its leaves are pale green in color. Its specific gravity is about 0·7 green and 0·5 seasoned. It is used for light carpenters' and joiners' work, and is remarkably well adapted to pattern makers' use. It has been employed to a considerable extent in building wooden bridges. It is not a very strong wood, and swells or shrinks seriously when the hygrometric state of the atmosphere changes considerably. For many purposes its softness is a serious objection.

The American Yellow Pine, "Spruce Pine," or short-leaved Pine (*Pinus mitis, Pinus variabilis*), is found throughout the country, in dry sandy soils, from New England to Georgia. It is much used in carpentry, and for framing and flooring, and in ship building; it is also used for the masts and yards of large vessels. The trunk is straight and slender. The heart wood is fine grained, moderately resinous, strong and durable. The sap wood is poor in quality, and decays rapidly. Its cones are small; its leaves are in groups of threes, and from 3 to 5 inches long. It attains a height of 60 feet and a diameter of 18 inches.

The Southern Pine, "Long-leaved Pine" (*Pinus Australis, Pinus palustris*), is distributed along the Atlantic coast from Maryland southward, on sandy, light soil. It is probably the most generally useful of our woods, and immense quantities are brought into market.

Its name is sometimes confused with that of the *pitch pine*, and both kinds of wood are known in the Eastern States as *hard pine*.

Both kinds are extensively used by Atlantic ship builders for planking, beams, etc., but seldom for any part of the frame.

The yellow pine sometimes attains a height of 150 feet and a diameter of 4 feet; but the pitch pine seldom exceeds two-thirds this size. The former is principally obtained from the States of Virginia, North Carolina and Georgia, while the latter is abundant in all the Atlantic States south of Chesapeake Bay. The yellow pine required for navy yard use is described as long-leaved, fine-grained Southern yellow pine. Its leaves are light green, 8 to 11 inches long, and rigid; they are dark green in color. The cones are 6 to 8 inches long.

It has but little sap wood, and the heart wood is of very uniform quality, its resinous matter being very regularly distributed. Its grain is fine and close, and it has greater strength, durability and hardness than any other species of pine.

Though not as tough and elastic as white oak, the yellow pine, especially that from Georgia, successfully rivals it in stiffness. If a beam of each kind of timber, equal in dimensions, be suspended by the ends, the oak beam will depart most from its "mould," but will break under about the same load. In dry situations the pine is extremely durable, and where the properties of lightness and solidity are required in combination it is to be preferred to oak. Experiments upon the shrinkage of various woods by Mr. James Jarvis, at the U. S. Navy Yard, Norfolk, Va., indicate that yellow pine should be cut in summer.

The Locust or common Acacia (*Robinia pseudo-acacia*) is a flowering tree, found in the mountainous and hilly portions of the country from Canada to the Southern States.

It grows rapidly and reaches a height of 70 feet with a diameter of 4 feet, but is usually considered full grown if 40 feet high and a foot in diameter. It is a fine ornamental tree.

The wood has a peculiar greenish-yellow color, resembling boxwood slightly. The structure is alternately very compact and quite porous. Its annual rings are thus very distinctly marked.

It exhibits no medullary rays, and the wood has neither taste nor odor. When of good quality it is difficult to cut and work. It is a very valuable timber.

It is especially valued for fence posts and rails, or boarding, but is seldom found of sufficient size and in quantity sufficient to be used in the latter form. It turns well in the lathe and has great torsional strength and resilience, excelling all other common woods in this quality.

The Ash (*Fraxinus excelsior*) *of Europe and the White Ash* (*Frax-*

inus Americana) of America are also valuable timber trees. Their woods have many useful applications. Ash is quite similar in color to oak and in texture to chestnut. It is straight-grained, remarkably tough and elastic, excelling all other common woods, and answers admirably for handspikes, heavy oars, ship blocks, tool handles, the wooden portions and framing of machinery, and for wheel carriages and agricultural implements. It is durable under cover, but decays rapidly if exposed to the weather. The tree grows to a height of 60 feet, and acquires a diameter of 20 inches in rich, moist, loamy soil. It has no observable sap wood.

The Black Walnut (*Juglans nigra*) is found throughout our Middle and Western States, and as far south as the Gulf of Mexico. The tree presents a fine appearance, attains considerable size, and yields a much-prized timber.

The wood varies considerably in quality. It is of a brown color, approaching red in some specimens, and of a dark chocolate color in others. The sap wood is frequently quite light in color. The best wood has a fine grain and a dense structure, although usually excelled in both particulars by good mahogany.

It is strong, durable and easily worked. It is more generally used in the United States for furniture and for ornamental purposes than any other wood, and immense quantities of it are annually worked up. It is nearly as strong as mahogany and is tougher.

The Live Oak (*Quercus virens*) is one of the best known ship-timber trees. It is evergreen and grows on the sea coast from Maryland to the Gulf of Mexico and the Mississippi, and is now so scarce and so valuable that the government has reserved all of the Florida live oak forests for naval purposes.

This timber is used almost exclusively for the purposes of ship building. It is heavy, compact, fine-grained, yellowish in color, and is the strongest and most durable of all American woods.*

The tree grows to a height of 60 feet, and to a diameter of 4 feet, but is usually 40 or 45 feet high and 12 to 18 inches in diameter. The capillary vessels of the heart wood are filled with a gummy substance; unlike other varieties of oak in our country, it is free from acid.

Live oak is not well adapted to the reception of spike fastenings, as

* The writer possesses a live oak cane taken in 1865 from the keel of the frigate *United States*, a naval vessel built very early in the present century. It is as perfectly sound, apparently, as when first cut.

the grain refuses to receive the point in the cutting direction, and permits splitting of the wood. There is no difficulty, however, in fastening with bolts and tree-nails. The sap wood is whitish in color, and is free from the glutinous matter found in the dense heart wood. Live oak, if exposed long in the open air, in the rays of the sun, or to winter winds, will check badly. It does not require many months of air-seasoning, however, to fit it for its ordinary uses. It is the most costly ship timber in the market.

The White Oak (*Quercus alba*) is a more common and a very valuable variety, and is in extensive use, especially for ship building, for which its trunk furnishes the heavier timber, and its large roots and branches yield the "compass timber." It is used for water-wheel shafts and other millwrights' work. The bark is of great value for tanning.

This tree is found from Canada to the Carolinas, and is most abundant in the Middle States, forming large forests west of the Alleghany range of mountains. It reaches a height of 80 feet and more, and its trunk is sometimes 6 or 7 feet in diameter. It is one of the few trees which retain any of their leaves throughout the winter. The leaf is deeply indented, long and narrow. Its bark is of a light grayish-white color, giving it its name; its wood is light straw colored, with a tinge of red, and is very tough, strong, durable, elastic and pliable, with strong lateral cohesion. It is very liable to shrink, warp and crack in seasoning, and is therefore of little value for boards. It is used for artillery carriages and makes very good steps for the lower ends of turbine water-wheel shafts. The shrinkage amounts to about $\frac{1}{32}$.

The wood of trees sixty to one hundred years of age is much tougher, particularly on high lands, than that of older trees. The wood from the roots makes beautiful furniture. The cost and the difficulty of working it preclude its extensive use. No certain data exist for comparing the properties of white oak grown in various districts, but it is generally supposed that the best timber for durability is that grown near the Atlantic seaboard or along the borders of the great lakes. Generally the strongest timber is grown on wet lands. The experiments of Jarvis prove, first, that there is ten per cent. in one year and five per cent. in four years more shrinkage in weight of the squared timber which is cut in the warm season than in that cut during the cold season; secondly, that in case of round logs, in bark, there is eight per cent. in one year and seventeen per cent. in four

years more loss by evaporation if cut in the summer season. It has a specific gravity of from 0·7 to 1·1, weighing from 44 pounds dry to 70 pounds when green per cubic foot.

THE FORM AND DIMENSIONS OF TEST-PIECES used in these experiments (see Figs. 1 to 4) were, as at first prepared, given in the accompanying figures:

FIG. 1. Tension.

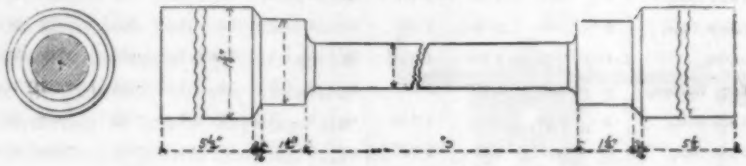


FIG. 2. Compression.

FIG. 3. Transverse.

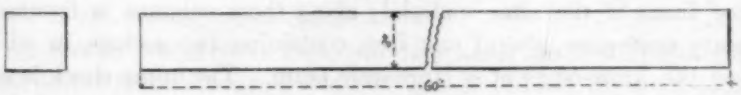
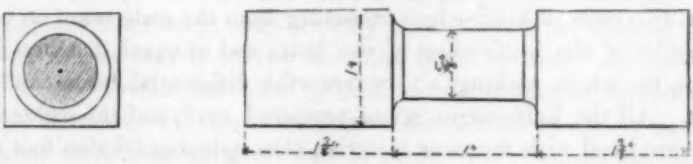


FIG. 4. Torsion.



The white pine here described was of light color and weaker than really good pine should be. Among other samples tested subsequently one bore double the load which broke this. The fact is a good illustration of the great variability observed in the strength of timber. The yellow pine was of fine quality, as were the locust and the oaks. The ash was a little too dry, but otherwise excellent.

The following table exhibits their sizes and densities:

TABLE OF DIMENSIONS AND DENSITIES OF WOODS.

NAME.	No. 1. Tension.		No. 2. Compression.		No. 3. Transverse.				No. 4. Torsion.		Weight per cubic inch in pounds.	Weight per cubic foot in pounds.
	Length.	Diameter.	Length.	Diameter.	Length.	Breadth.	Depth.	Distance between supports.	Length.	Diameter.		
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.		
White Pine,	4	·537	2·25	1·117	60	3	3	54	1	·780	·0017	29·376
Yellow Pine,	4	·532	2·25	1·102	60	3	3	54	1	·760	·0270	46·656
Locust,	4	·522	2·25	1·078	60	3	3	54	1	·656	·0330	57·024
Black Walnut,	4	·535	2·25	1·112	60	3	3	54	1	·785	·0220	38·016
White Ash,	4	·544	2·25	1·104	60	3	3	54	1	·762	·0200	34·560
White Oak,	4	·481	2·25	1·117	60	3	3	54	1	·780	·0240	41·472
Live Oak,	4	·497	2·25	1·117	60	3	3	54	1	·656	·0390	67·392

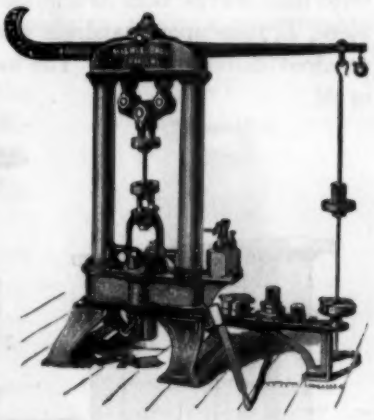
THE TESTING MACHINES used in this work were the standard machines of the Mechanical Laboratory of the Stevens Institute of Technology. The tension and compression machine is of a peculiar design, which has never been reproduced, and which was supplied to the writer by Messrs. Riehlé Brothers, of Philadelphia.

It consists of two strong cast iron columns, secured to a massive bed frame of the same material; above these columns is fastened a heavy cross-piece, also of cast iron, containing two sockets, in which rest the knife-edges of a large scale-beam. The upper chuck is suspended by two eye-rods from two knife-edges, $\frac{1}{2}$ inch to one side of centre of a heavy wrought iron block, which is hung by two links from two pairs of knife-edges projecting from the scale beam on opposite sides of the knife-edges of the latter and at equal distances from them, the whole making a very powerful differential beam combination. All the knife-edges are of tempered steel, and the sockets and eyes are lined with the same material, thus reducing friction to a minimum. The load is applied by means of a hydraulic press, with a fixed plunger and movable cylinder; to the latter the lower chuck is fastened by means of an adjustable staple and link. The stress to which the test-piece is subjected is measured by means of suspended weights and a sliding poise. The specimen is secured in the chucks, either by wedge-jaws or cored chucks, according to the specimen to be tested. The capacity of the machine is twenty tons. Fig. 5 exhibits the machine with the sliding poise and adjusting apparatus omitted.

The extensions were measured by means of an instrument in which

contact is indicated by an "electric contact apparatus." The instrument consists essentially of two very accurately made micrometer screws, working snugly in nuts secured in a frame which is fastened to the head of the specimen by a screw clamp. It is so shaped that the micrometer screws run parallel to and equidistant from the neck of the specimen on opposite sides. A similar frame is clamped to the lower head of the specimen, and from it project two insulated metallic points, each opposite one of the micrometer screws. Electric connection is made between the two insulated points and one pole of a voltaic cell, and also between the micrometer screws and the other pole. As soon as one of the micrometer screws is brought in contact with the opposite insulated point a current is established, which fact is immediately revealed by the stroke of an electric bell placed in the circuit. The pitch of the screws is 0·02 of an inch, and their heads are divided into 200 equal parts; hence a rotary advance of one division on the screw head produces a linear advance of one ten-thousandth (0·0001) of an inch.

FIG. 5.



A vertical scale, divided into fiftieths of an inch, is fastened to the frame of the instrument and set very close to each screw head and parallel to the axis of the screw; these serve to mark the starting point of the former and also to indicate the number of revolutions made. By means of this double instrument the extensions can be measured with great certainty and precision, and irregularities in the structure of the material, causing one side of the specimen to stretch more rapidly than the other, do not diminish the accuracy of the measurements, since half the sum of the extensions indicated by the two screws is always the true extension caused by the respective loads.*

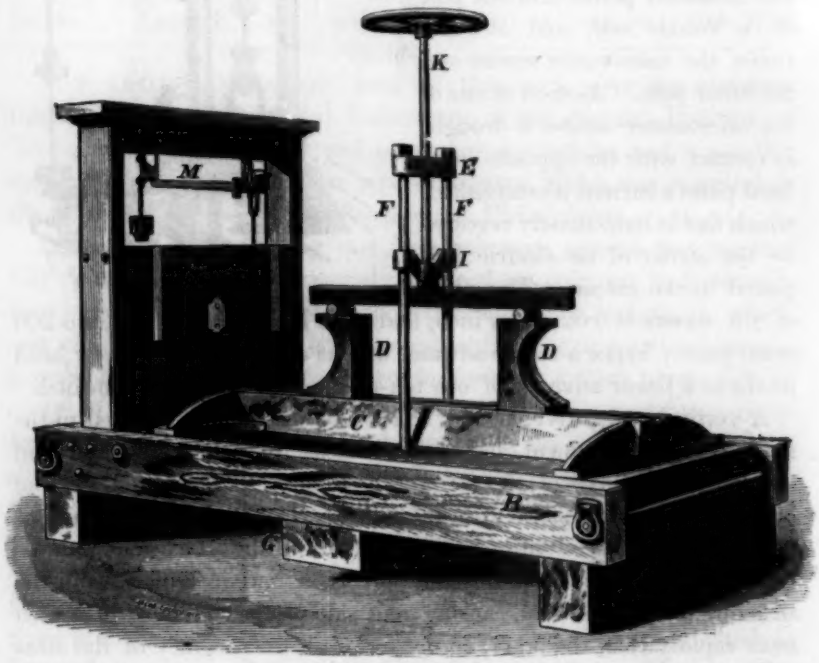
The machine used for tests of transverse strength was designed by

*This instrument is figured and described in a report by the U.S. Board, appointed to test iron, steel and other metals, in an investigation in the Mechanical Laboratory of the Stevens Instituto of Technology: "On the Properties of the Copper-tin Alloys." Washington: Government Printing Office. 1878.

the writer, and built by Messrs. Fairbanks & Co., of St. Johnsbury, Vt. It is shown in Fig. 6.

It consists of a Fairbanks scale, on the platform of which rests a heavy cast iron beam, *C*, to which are fastened the supports, *DD*, at the required distances apart. The pressure is applied by means of the hand-wheel on the upper end of the screw, *K*, which screw passes through the nut, *E*, and terminates in the sliding cross-head, *I*. This cross head serves both as a guide and as a pressure-block. The test-piece, *L*, rests upon mandrels mounted upon the supports, *DD*, at the required distance apart. The loads are weighed in the usual manner at *M*.

FIG. 6.



The instrument for measuring deflections is not shown in the cut; it consists of an accurately cut micrometer screw of steel, having a pitch of 0·025 of an inch, working in a nut of the same material mounted in a brass frame. This instrument is supported by a rod of considerable rigidity and of sufficient length, which is secured to the beam, *C*, close to the tension rods, *FF*, in such a manner that the micrometer is

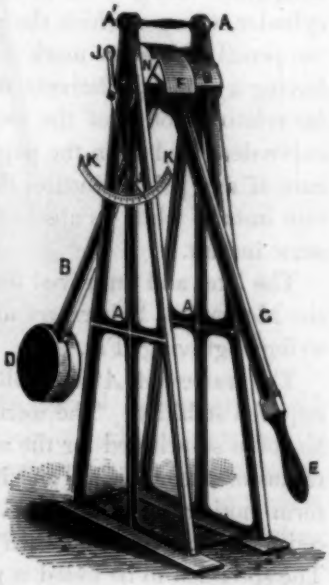
directly over the cross-head, in the same vertical plane with the test-piece, and very near and parallel with the axis of the large screw, *K*. The micrometer screw is provided with a head which is divided into 250 equal parts. Thus, a rotary motion of one division produces an advance in the direction of the axis of the micrometer screw of 0·0001 of an inch. A scale divided into fortieths of an inch is fastened to the frame of the instrument, in close proximity to the head and parallel to the axis of the screw; it serves to mark the starting point and indicates the number of revolutions made in taking a measurement with the screw.

To insure accurate readings of the deflections the principle of electric contact is also employed here.

The capacity of the testing machine is 7000 pounds.

The testing machines used for torsion-tests in the Mechanical Laboratory of the Institute are two styles of "Autographic Recording Testing Machines," devised by the writer. They had previously produced a considerable mass of records which have been, in part, presented by the writer, with interpretations, to the American Society of Civil Engineers.*

Fig. 7.



The machine employed in the earlier tests is shown in Fig. 7. Two strong wrenches, *CE*, *BD*, are carried by the frames *AA*, *A'A'*, and depend from axes which are both in the same line, but are not connected with each other. The arm, *B*, of one of their wrenches carries a weight, *D*, at its lower end. The other arm, *C*, is designed to be moved by hand in the smaller machines, and by a gear and pinion, or a worm gear, in larger forms of the apparatus. The heads of the wrenches are made as shown in Fig. 8, the recess, *M*, being fitted to take the head, on

Fig. 8.

* See Trans. Amer. Soc. C. E., 1876, *et seq.*

the end of the test pieces, which is usually given the form shown in Fig. 4.

A guide curve, *F*, of such form that its ordinates are precisely proportional to the torsional moments exerted by the weighted arm, *BD*, while moving up an arc, to which the corresponding abscissas of the curve are proportional, is secured to the frame, *AA'*. The pencilholder is carried on this arm, *BD*, and as the latter is forced out of the vertical position, the pencil is pushed forward by the guide curve, its movement being thus made proportionate to the force which, transmitted through the test piece, produces deflection of the weighted arm. This guide-line is a curve of sines. The other arm, *CE*, carries the cylinder, *G*, upon which the paper receiving the record is clamped, and the pencil makes its mark on the table thus provided. This table having a motion, relatively to the pencil, which is precisely the angular relative motion of the two extremities of the tested specimen, the curve described upon the paper is always of such form that the ordinate of any point measures the amount of the distorting force at a certain instant, while its abscissa measures the distortion produced at the same instant.

The later and improved form of machine, as now built and used in the Mechanical Laboratory of the Institute, is shown in the accompanying engraving, Fig. 9.

The frames, *A*, *A'*, are bolted to a heavy bed-plate, which secures the required stability. The worm wheel, *M*, engaging with the worm, *L*, has been substituted for the arm, *CE;* the worm is set in motion by means of the crank, *L*, and in this manner a very slow and quite uniform motion can be obtained. Both wrenches are provided with lathe-centres directly opposite each other and in the common axis of rotation. The specimen to be tested is placed upon the lathe centres, which hold it in line while it is being secured in the jaws of the wrenches by means of steel wedges inserted from opposite sides.

Supposing a test-piece to be placed in the machine; the operator turns the crank, *L*, with a uniform velocity which gives a slow and a very steady motion to the wrench connected with the worm wheel, which is transmitted through the test-piece to the wrench carrying the weighted arm. The latter is moved by the force transmitted through the test-piece through an arc, which is a measure of the resistance to torsion offered by the test-piece, and is recorded simultaneously with the angle of torsion by the pencil, as explained above.

The drum carrying the record sheet is of such a diameter that the circumference is 36 inches, which, when divided into tenths, makes 360 divisions, each of which is representative of one degree.

Fig. 9.

In the machines employed in the Mechanical Laboratory of the Stevens Institute of Technology each inch of ordinate denotes 100 foot-pounds of moment to have been transmitted through the test-piece, and each inch of abscissa indicates 10 degrees of torsion. The friction of the machine is not recorded by the machine, but is added in calculating the results.

By means of this machine the metal tested is compelled to tell its own story, and to give a permanent record and graphical representation of its strength, elasticity and every other quality which is brought into play during its test, and to exhibit its characteristic peculiarities.

The machine first described was selected for use in this research and was altered to meet the special requirements of the case. The lever arm, even without the weight, giving too great a moment of resistance for some specimens of wood of the usual diameter, a counterpoise was arranged, consisting of a bar of iron bent to a rectangular shape and clamped to the lever arm below the guide curve, of such a size that,

when the lever arm was deflected, it would not interfere with the guide curve. To the top of this rectangle was fastened a vertical iron rod, to which was attached a weight by means of a set screw, so arranged that the continuation of the vertical axis of the lever arm should coincide with the vertical axis of the rod and weight.

In the diagrams produced by the machine thus modified, every inch of ordinate represents 1·058 ft.-lbs. plus the friction of the machine, which in this case is equal to ·52 ft.-lbs.; the horizontal scale is the same as above, *i. e.*, one inch of abscissa equals 10 degrees of twist.

THE EXPERIMENTS were made, as stated, in the Mechanical Laboratory of the Stevens Institute of Technology. The immediate charge of the machines and the observation of results of tests was entrusted to Mr. Frank P. Jones, M. E. (Class of '78), to whose care, skill, industry and persistence we are indebted for a series of very valuable determinations.

The results were tabulated by Mr. Jones, who, under the direction of the writer, also prepared a series of curves graphically representing them. The whole investigation was fully described in a graduating thesis.* The tables here given are usually presented with little or no material alteration as calculated by Mr. Jones in his thesis.

THE TERMS USED may be thus defined:†

The Modulus of Rupture for Tension is the force necessary to pull asunder a bar whose section is one square inch when acting in the direction of the axis of the bar.

The Modulus of Rupture for Compression is the pressure necessary to crush a piece of any material whose section is unity and whose length does not exceed from one to five times its diameter.

The Modulus of Rupture for Transverse Stress is the strain at the instant of rupture upon a unit of the section which is most remote from the neutral axis on the side which first ruptures.

The Modulus of Torsion is the ultimate resistance to torsion of a unit of the transverse section most remote from the axis of torsion.

The Modulus of Elasticity is a value which expresses the relation

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*"Strength of Woods used in Engineering." By Frank P. Jones, M. E, '78. MSS; small 4to; pp. 75; folding plates xvii. Library Stevens Institute of Technology. 1878.

†See Woods' "Resistance of Materials," and "Report," by the writer, "on Cold-rolled Iron and Steel." Pamphlet. Pittsburgh, 1878. And also "Report on the Copper Tin Alloys." Washington: Government Print. 1879.

between the extension, compression or other deformation of a bar and the force which produces the deformation.

Resilience is a measure of the capacity of a material to resist shock, and its value is equal to the amount of energy expended, or the "work" performed in producing distortion or rupture.

The tension-tests gave the following results:

RESULTS OF TESTS BY TENSION.

Wood.	l	d	Modulus of Rupture.	Modulus of Proof Stress	Modulus of Elasticity.	Resilience.		Extensions. Per ct. of length.	
						Ultimate.	Elastic.	Total.	At elastic limit.
	in.	in.						in.	in.
White Pine,	4	·527	6877·5	3900	183486·2	2467·5	720·0	·725	·400
Yellow Pine,	4	·532	2070·2	13200	240240·2	21457·0	3940·0	1·650	·625
Locust,	4	·522	28925·2	19200	373831·7	31170·0	10792·5	1·850	1·100
Black Walnut	4	·535	9786·4	5700	213523·1	4022·5	1530·0	·850	·525
White Ash,	4	·544	15490·5	97000	206540·4	12695·0	3855·0	1·475	·775
White Oak,	4	·481	13207·8	8100	220130·9	7500·0	3022·5	1·300	.770
Live Oak,	4	·497	10309·2	6300	247505·2	5887·5	2167·5	1·150	·575

In calculating the results of tension-tests, as presented in the table, the *Resilience* was obtained, as in all other cases, by first plotting the results of test and obtaining a curve of which the ordinates measure loads and the abscissas the corresponding stretch or other form of distortion, then measuring the total area of the curve to obtain a measure of total resilience, or shock-resisting power, and by taking the area within the ordinate at the elastic limit as the measure of the elastic resilience.*

The Modulus of Rupture is measured by $R = \frac{P}{K}$; in which P is the load producing rupture, K is πr^2, the sectional area at the point of fracture, and R is the modulus.

The Modulus of Proof Stress is similarly obtained, taking for P the load producing permanent distortion, as measured at the elastic limit.

The Modulus of Elasticity is $E = \frac{Pl}{yK}$; in which its measure, E, is obtained in terms of: P, which is the load at the elastic limit; l is the length of the part stretched, *i. e.*, of the "neck" of the test-piece;

* The resilience, as usually defined, is *elastic* resilience. It should be carefully distinguished from *total* resilience. The one is proportional to the *work*, or the *vis viva*, required to produce permanent distortions; the other measures that required to produce fracture.

y is the extension at the elastic limit, and K is πr^2, the area of cross-section at the part fractured. The position of the "elastic limit," so called,, is necessarily assumed, since, as is seen by examination of the strain-diagrams, which graphically represent the results of these experiments, there is no definite elastic limit, the woods, as was shown by Hodgkinson to be the case with cast iron, having no true elastic limit; but take a set with any load however small. The point assumed is indicated in each case. It may be considered by many that a more strictly accurate measure would be obtained by deducing it from the direction taken by a tangent to the strain-diagram line at its origin. Either method will answer every practical purpose.

The calculations relating to compression were similarly made, assuming that the laws affecting wood under compression are the same as those acting when it is broken by tension—a practically correct assumption where the test pieces, as in this case, are crushed without lateral flexure.

THE RESULTS OF TEST BY COMPRESSION are presented in the following table:

RESULTS OF TESTS BY COMPRESSION.

WOOD.	l	d	Modulus of Rupture.	Modulus of Proof Stress	Modulus of Elasticity.	RESILIENCE.		COMPRESSION. Pr.ct. of length	
						Ultimate.	Elastic.	Total.	At elastic limit
	in.	in.							
White Pine,	2·25	1·117	9592·6	5600	6521·8	19542·6	3534·3	3·498	1·584
Yellow Pine,	2·25	1·102	11952·3	7000	8576·9	16576·56	4107·18	2·906	1·485
Locust,	2·25	1·073	14818·9	9800	8713·8	26551·14	5761·14	3·300	1·617
Black Walnut	2·25	1·112	7001·7	5700	21060·5	5382·6	1561·56	1·254	·528
White Ash,	2·25	1·104	8148·3	5180	17810·0	12788·16	1898·82	2·310	·726
White Oak,	2·25	1·117	7143·5	5600	8029·0	15868·8	3940·86	3·300	1·551
Live Oak,	2·25	1·117	10409·2	6300	14910·5	23150·82	3100·02	3·366	1·056

THE TESTS BY TRANSVERSE STRESS gave results which are exhibited in the succeeding table. Here the modulus of rupture is $R = \sqrt{\frac{3}{2}\frac{Pl}{bd^2}}$; in which expression P = load producing rupture; l = the length of the test-piece between supports; b = its breadth; d = its depth; all measures are in inches, and loads in pounds.

In determining the Modulus of Proof Stress the same expression is used, taking for P, however, the proof load, or the load at the real or assumed elastic limit.

The Elastic and the Ultimate Resiliences here given are the number of

foot-pounds of work done in straining the specimens tested to the elastic limit and to the point of rupture respectively, and may be taken as approximate measures of the shock-resisting power of the material.

The Modulus of Elasticity, or the relation of the amount of distortion to the load producing it is determined by the expression: $E = \frac{Pl^3}{48\,\Delta\,I}$, in which P is the load corresponding to a deflection, Δ, midway between supports; l is the length from support to support; Δ is the amount of deflection, and I the moment of inertia; for these rectangular sections, $I = \frac{bx^3}{12}$.

RESULTS OF TESTS BY TRANSVERSE STRESS.

Wood.	l	b	d	Modulus of Rupture.	Modulus of Proof Stress	Modulus of Elasticity.	Resilience.		Deflection.	
							Ultimate.	Elastic.	Ultimate.	At elastic limit
	in.	in.	in.						in.	in.
White Pine,	54	3	3	5280	4320	883636	1364·8	634·8	1·28	·86
Yellow Pine,	54	3	3	16740	12720	3534727	4174·4	2039·6	1·96	·84
Locust,	54	3	3	13680	8400	2046315	4843·2	1259·2	2·70	·82
Black Walnut,	54	3	3	7440	5640	1944000	971·6	433·2	·72	·50
White Ash,	54	3	3	9720	6360	1080000	533·3	1212·6	2·50	1·50
White Oak,	54	3	3	9840	7200	1620000	3660·8	1227·2	1·76	.90
Live Oak,	54	3	3	11280	9040	1851428	4601·6	1462·4	1·38	·94

TESTS BY TORSION were made in the Autographic Machine, modified as already described.

Elasticity is measured by $E = \frac{r}{h}$, in which r is the measure of the recoil on removal of the load, and h the measure of the stress on the diagram taken from base-line.

Stiffness is measured by $S = \frac{m}{o}$, in which o measures the angle of torsion to the point considered (within the elastic limit), and m the value of the corresponding ordinate.

The Modulus is obtained by the expression $E = \frac{ml}{oh^5}$, in which m and o have the values assigned above; l = length of neck of test-piece, and h = its diameter.

The Resiliences, elastic and ultimate, come from the expressions $e = a\frac{m}{R} + F\frac{l}{R}$, and $E = A\frac{m}{R} + E\frac{l}{R}$, in which a is the area of

curve to the elastic limit; A is its total area; l = length of abscissa; R = radius of the drum carrying the sheet; m = foot-pounds per square inch of area of curve.

RESULTS OF TESTS BY TORSION.

Wood.	l	d	Resilience.		Elasticity.	Stiffness.	Elastic Modulus of Resistance to Torsion.
			Ultimate.	Elastic.			
	in.	in.					
White Pine,	1	·780	5·10	·235	.....	·443	1·534
Yellow Pine,	1	·760	12·425	·238	.....	1·744	6·878
Locust,	1	·656	14·067	·178	.....	1·720	14·159
Black Walnut,	1	·785	7·396	·238	.....	1·088	3·650
White Ash,	1	·762	7·381	·560	.....	·598	2·328
White Oak,	1	·780	12·777	·396	.....	·911	3·155
Live Oak,	1	.656	14·570	·631	.....	·474	3·902

COMPARING AUTHORITIES on the strength of woods, it will be found that the results here recorded usually differ from those obtained by earlier experimenters, and that these figures are almost invariably higher than those of Barlow, Tredgold or Laslett, a fact probably attributable to the very uniform excellence in quality of the specimens tested, although it is possible that they may prove superiority of the American to the European timber.

The American timber, as here tested, gives figures in tension from one-eighth to one-fourth higher than the European woods reported on by Barlow or Tredgold, with the exception of ash. Tredgold's figures for American woods are, however, lower than those here presented, which is evidence of a difference in quality of test-pieces rather than of differences in the varieties of timber. The tables of resistance of timber given in Wood's "Resistance of Materials" accord more closely with those here obtained than do those given frequently elsewhere; they are, however, usually lower than these.

Comparing the results of torsional tests with those previously obtained by the writer,* by a similar method, they were found substantially to agree. The later experiments of Mr. Jones do not exhibit the peculiar phenomenon of a depression and subsequent re-elevation of the curve of the strain diagram which is exhibited in some cases in the earlier records. This may be due to the more complete

*"On the Strength, Elasticity, Ductility and Resilience of Materials of Machine Construction, etc." Trans. Amer. Soc. of C. E., JOURNAL OF THE FRANKLIN INSTITUTE, 1874.

seasoning of the test pieces last used, or to the action of the modified machine, which was less free from friction, and therefore somewhat less sensitive than was that first used by the writer.

In all cases the test-pieces here described were prepared from selected wood, straight-grained, free from knots or other perceivable defect, and may probably be considered as representative of the best quality of American timber, with the exception of the specimen of pine already mentioned. They were measured, when brought to size, by callipers, reading to $\frac{1}{1000}$th inch.

Results were carefully corrected for the local crushing of the wood at points of contact with the machine.

The characteristics of the several woods are best shown by the autographic strain diagrams, of which two sets are given. The one giving the line of recoil when the load was removed at the elastic limit, the other exhibiting the full curve up to the point of final rupture. The areas of these curves were measured very carefully by Mr. Jones, using an excellent planimeter reading to $\frac{1}{100}$th square inch.

The results recorded in this paper are those obtained from the standard set of test-pieces. Repeated experiments on test-pieces from the same timber gave substantially the same results.

American timber has a value, in construction, equal, if not decidedly superior to, European timber.

The strength of American timber, as given by earlier authorities, is probably that of average specimens, and timber may be obtained by careful inspection of very much greater value.

Timber yields, under all forms of stress, to an extent which may be taken, as with cast iron, to be proportional to the load.

From what is above stated, and from a study of the strain diagrams, it may be concluded that the strength of timber is so variable that the only safe course in construction is to assume the highest values, determined by the most uniform series of tests of the material proposed to be used, and then to adopt a high factor of safety.

The tables above given may probably be taken to represent the probable values of resistance of the best selected woods, such as are passed by inspectors for naval purposes.

THE FUTURE WATER SUPPLY OF THE CITY OF PHILADELPHIA.*

By James F. Smith, C. E.

So much has been said and written on the subject of the water supply of Philadelphia that one may well feel a delicacy in making any further reference to it. The writer has, however, devoted some leisure time and study to its consideration, and, in common with others, appreciates the great importance to the city of Philadelphia of a never-failing and abundant supply of pure and wholesome water.

In the year 1875, when the Commission of Engineers had under consideration the water supply of the city, the writer made certain suggestions, namely: First, the creation of a system of storage dams in the Schuylkill, where the river was not already occupied by the Schuylkill Navigation Company's works, and the use of several dams of the upper navigation, and the reservoirs now existing or to be created in the valley of Tumbling Run, near Pottsville; second, utilizing more fully the water-power at Fairmount and at Flat Rock dams, by raising these dams and increasing the volume of water from the storage dams when required; third, the building of an aqueduct to lead the water from the Flat Rock dam to the pumping stations at Spring Garden, Belmont and Fairmount, so that pure water might be supplied free from the contaminations and impurities of the Fairmount pool.

These plans were adapted to the wants of the existing water supply from the Schuylkill, and to the increase and improvement of the same. This supply is dependent upon steam-pumps with high lifts and inadequate water-power. Coupled with these disadvantages is the liability to breakage and derangement of pumps and power; whereas the people of a great city with dependent manufacturing establishments need a constant, reliable and ample supply of water of a purity that may not be questioned. Purity of supply can only be had by a resort to streams of water originating in the hills or ridges where the population is sparse and the country not extensively under cultivation. For

* A portion of this article appeared in the *North American*.

Philadelphia, the Perkiomen creek and its tributaries, rising in the spurs and ridges of the South mountain in Berks county, and in the elevated water-sheds of Bucks county, midway between the Delaware and the Schuylkill, is the source from which the water must come, and gravity the mode of its conveyance.

The citizens of Philadelphia have been made somewhat familiar with the question of a gravity supply from the Perkiomen by the consideration of Mr. Birkinbine's plan as given in the "Report of the Commission of Engineers" in 1875, and in his reports and papers on the subject.

The plan proposed by Mr. Birkinbine for an impounding reservoir is, indeed, favorable for the creation of a large lake, by the erection of a dam seventy or seventy-five feet in height, except in one particular, namely, the great length of the mound dam that would be required. The Commission of Engineers regarded this project with considerable favor, and gave credit, not improperly, to Mr. Birkinbine for his foresight in suggesting it. But at the site selected the water surface of the proposed lake would be too low for the city, except for the supply of the East Park Reservoir and the basins below its level, namely, Schuylkill, Corinthian avenue, Delaware and Fairmount; and from what has been said by the Commission, it will be observed that the conduit from this lake was not designed to deliver water into a receiving basin in the city at a greater elevation than 133 feet above city datum. This is manifest from what they say, namely, "that thorough and careful surveys should be made of the location of the line of conduit from the Perkiomen dam to the East Park Reservoir."

This deficiency in elevation, it must be admitted, is fatal to Mr. Birkinbine's location, as it would not be wise to build an aqueduct line to bring in the water of the Perkiomen, only to deliver it into the East Park Reservoir, at an elevation too low to supply Belmont, Frankford, or the proposed Cambria basins. The surfaces of the two former of these are respectively 212 and 168·40 feet above city datum, or 217·38 and 173·78 feet above mean tide, Delaware river, and the proposed Cambria basin about 170 feet above city datum.

My attention has but lately been called to an article on the subject of a gravity supply from the Perkiomen, by Chas. G. Darrach, C. E.*

Mr. Darrach proposes, instead of Mr. Birkinbine's lake, an inter-

* *Proceedings of the Engineers' Club of Philadelphia*, Vol. 1, No. 3, p. 162.

cepting canal around the valley, the supply for which is proposed to be taken from impounding dams to be erected on the main stream and its branches. This plan is ingenious and an improvement on that of Mr. Birkinbine in several particulars, namely, increased elevation, a delivery into the receiving basin of the city at an elevation of 170 feet instead of 133, and saving from destruction the Perkiomen railroad and the improvements in the valley which would be submerged by the lake.

Among the objections to the plan is still the want of elevation. A gravity supply to meet the future wants of the city of Philadelphia should deliver the water into the receiving basin at a much higher elevation than 170 feet of city datum, in view of the certain future extension of improvements and spreading of population over those parts of the city which are now suburban.

The plan for a gravity supply by aqueduct from Perkiomen, which I now propose, meets the objection of the want of height of Mr. Birkinbine's location. It will not require any alteration in the line of the Perkiomen Railroad, which would be necessary should a dam be erected near Schwenksville, and a large amount of valuable property in the valley of the main stream between that point and Green Lane would be saved from destruction.

The Location.

On the main stream of the Perkiomen, a few hundred yards above the Green Lane station of the Perkiomen Railroad in Montgomery county, eighteen miles above the mouth of the creek, there is an admirable site for a dam, at a point where the stream has broken through a ridge of hard rock, leaving a gap of little more than three hundred feet across with precipitous sides and solid foundations, just adapted to the erection of a safe and durable structure. At this place the dam may be 90 to 100 feet high, backing the water several miles into a valley, with favorable slopes bounded by hills and ridges.

From this dam I propose to carry the water by an aqueduct into the city, and the aqueduct would be so located as to command from 45 to 50 feet in depth of the storage water of the dam.

The Course of the Aqueduct Line—its Length, Terminal Basin and Elevation.

The route may be thus described: Commencing at the storage dam

or lake, and crossing the Perkiomen Railroad at a sufficient elevation above it, the aqueduct pursues a course nearly straight to the Plymouth Valley, passing a little west of the dividing ground between the waters of the Wissahickon and Plymouth creek, about twenty miles from the starting point at Green Lane.

Advancing from this point, after crossing the Plymouth Railroad, the line reaches Barren hill and passes through it into the Wissahickon valley; thence down that valley on the eastern slope of the ridge, crossing the stream, not far from Hermit's lane, to the high ground in the vicinity, where a distributing reservoir, of very moderate dimensions, in connection with the several existing basins of the water-works and the East Park Reservoir when completed, would suffice, and furnish a storage capacity of nearly one billion of gallons. The length of the proposed aqueduct line is about 27½ miles, and the location such that the water may be delivered into a receiving reservoir, the surface of which might be 240 feet above city datum, with a free delivery from the aqueduct itself, the water surface of which when running in its full capacity would be nearly 249 feet above city datum, or 254 feet above mean tide Delaware river.

It may be stated here in regard to the line of the conduit, that whilst none of the valleys to be crossed will require long and elevated structures of masonry, there will be several tunnels, mostly through sandstone. Below Barren Hill the work will encounter mainly gneiss rock. This feature is deemed favorable, as tunneling at the present time, owing to improved methods and explosives, can be done with such great facility that in most cases the expense will be less than for an aqueduct of masonry, and especially so where the rock encountered is found to be of a character to justify the omission of interior brick linings.

Tributaries of the Perkiomen Intercepted.

In the first 10½ miles a number of important streams are passed. Three of them are main branches of the Perkiomen, and three affluents of these branches. They originate chiefly in the hills dividing the waters of the Delaware from the Schuylkill in Montgomery and Bucks counties, more than 500 feet above tide, and extremely favorable for maximum precipitation. It is part of the plan that these streams shall be made tributary to the water supply by the erection of impounding dams or small lakes upon them, with dams of the heights and capacity

suited to their drainage areas and the quantity of water required to be stored. The cost for all of them will not, it it is believed, be more than for the dam, and the land and improvements that would be submerged and destroyed by the lake at Schwenksville and the reconstruction of ten miles of railroad would be saved. At first the construction will be limited to the works at Green Lane and the aqueduct line to the city, leaving the improvement of the tributary streams to be undertaken one by one, in the future, as the increase in population of the city may demand more water for consumption.

Capacity of the Perkiomen Water Shed.

The water shed of the Perkiomen above Green Lane station is about seventy-three square miles, and with the tributary streams crossed by the aqueduct line added there is not less than 200 square miles. If 59 per cent. of the annual rainfall of 47·82 inches be taken as collectable (being one-fifth greater than that of the year 1858 at Philadelphia, and which Mr. W. J. McAlpine, C. E., has taken in his calculations for the Perkiomen, *vide* report of Commission of Engineers, 1875), it would give daily 272,000,000 gallons. Of this quantity it may be assumed that 165,000,000 gallons daily average supply to the conduit may be taken, leaving, after deducting for soakage, evaporation and waste of the impounding dams, nearly 100,000,000 gallons to pass away as surplus or flood water. From the Perkiomen above Green Lane village 60,000,000 gallons daily of the supply may be furnished, and when the consumption of water is greatest, in July or August, 72,000,000.

The drainage areas of the streams above the aqueduct line have been determined from measurements and calculations based upon a corrected map of the townships of Montgomery and parts of Bucks and Berks counties, which was specially prepared for the purpose. The results are believed to be fair approximations, and are given in the following table:

Table 1.

	Square miles.
Perkiomen Creek at Green Lane,	73·00
Great Swamp Creek,	34·47
Ridge Valley—affluent of Swamp Creek,	9·64
East branch of Perkiomen,	46·00
Indian Run—affluent of east branch,	6·04
Skippack Creek,	21·48
Towamencin—affluent of Skippack Creek,	10·55
Total,	201·18

Macoby Creek, a stream having a drainage area, above the aqueduct line, of 17½ square miles, flows into the Perkiomen at Green Lane, south of the railroad, but is omitted to avoid any interference with the road, which occupies the valley for several miles. This stream may be utilized to the extent probably of 10 square miles of its drainage area without injury to the railroad.

In the annexed table is given both the annual and the average daily flow of the seven streams, based upon the utilization of 28·41 inches of the rainfall upon the Perkiomen water shed; also the reservoir capacity required above the limit of draught in the impounding dams for a given consumption.

TABLE 2.

Name of Stream.	Collectable annually—Million U.S. gallons.	Daily average gallons.	Daily average demand for consumption—Million gallons.	Deficiencies to be provided for by storage dams—Million galls.
Perkiomen Creek,	36,041	98,742,466	60	3,996
Great Swamp Creek,	17,053	46,720,548	28	1,832
Ridge Valley,	4,751	13,016,438	8	560
East branch,	22,735	62,287,671	38	2,530
Indian Run,	2,959	8,106,849	5	365
Skippack Creek,	10,465	29,164,383	18	1,215
Towamencin,	5,193	14,227,397	8	592
	99,377	272,265,752	165	11,090

This table is constructed upon the basis of 47·85 inches annual rainfall, or one-fifth more than that of the year 1858 at Philadelphia, as assumed by Mr. McAlpine.

There are no records of rainfall upon the Perkiomen in years past with which comparison might be made to establish the correctness of the above assumed data. We have, however, actual results obtained from storage reservoirs in constant use in Eastern Pennsylvania, one example of which will suffice.

The Silver Creek reservoir of the Schuylkill Navigation, on the Broad Mountain in Schuylkill county, has a drainage area of $1\frac{275}{1000}$ square miles. This water shed is rolling table land, not rising in any part to the dignity of a hill, and therefore not very favorable to the flow of a large percentage of rainfall into the reservoir. Notwithstanding this fact it is filled at least twice every year, and this has been the experience of many years. Its capacity is 320,000,000 gallons, and the total quantity stored and utilized for supplying the navigation

is 320,000,000 × 2 = 640,000,000 gallons, = 28·82 inches of rainfall over $1\frac{275}{1000}$ square miles.

Upon the basis of this quantity utilized from $1\frac{275}{1000}$ square miles, applied to the Perkiomen drainage area of 201 square miles, we have 101,000 million gallons, as against 99,377 million gallons collectable from 28·41 inches of rainfall (Table 2).

It may be said that the region of Silver Creek, being at an altitude of 1500 feet above the level of the sea, is more favorable for rainfall than the Perkiomen district.

Distances and Fall of Aqueduct Line (circular).

NAME OF STREAM.	Distance from the reservoir.—Miles.	Total distance (per map).—Miles.	Total distance with allowance for deviation.—Miles.	Fall or descent.—Feet.	Total fall.—Feet.	Assumed level of water surf. in the aqueduct above C. D.—Feet.
West branch (Perkiomen),	0	0	0	0	0	275·
Great Swamp Creek,	1·375	1·375	1·39	$\frac{1}{3400}$	2·159	262·84
Ridge Valley,	0·500	1·875	1·89	$\frac{1}{4073}$	2·445	272·55
East branch,	1·875	3·750	3·80	$\frac{1}{4253}$	4·720	270·28
Indian Run,	1·250	5·000	5·05	$\frac{1}{4976}$	5·350	269·65
Skippack Creek,	3·875	8·875	8·95	$\frac{1}{3060}$	9·450	265·55
Towamencin Creek,	0·875	9·750	9·85	$\frac{1}{3480}$	9·630	265·37
Stony Creek Railroad,	4·625	14·375	14·52	$\frac{1}{3397}$	13·690	261·31
1st branch crossing Stony Creek,	0·875	15·250	15·40	$\frac{1}{3397}$	14·530	260·47
2d " " "	1·000	16·250	16·40	$\frac{1}{3397}$	15·470	259·53
3d " " "	1·500	17·750	17·93	$\frac{1}{3397}$	16·910	258·09
Plymouth Railroad Summit,	2·250	20·000	20·20	$\frac{1}{3397}$	19·050	255·95
Wissahickon,	6·875	26·875	27·15	$\frac{1}{3397}$	25·610	249·39
School Lane (high ground),	0·375	27·250	27·50	$\frac{1}{3397}$	25·940	249·06

I need only refer to so eminent an authority on climatology as Lorin Blodget in support of the contrary opinion. Mr. Blodget places the Schuylkill county region within the range of 40 inches mean rainfall, as against 42 inches in the Berks, Montgomery and Philadelphia districts, and, in an article on the climatology of Pennsylvania, says, fur-

ther: "The heaviest rainfall is in the southeast, where the annual mean is 48 inches, and the greatest quantity in any one year is about 60 inches. This represents the first range of hills back from the Delaware River, on which more rain falls than on the plains of New Jersey and Delaware, nearer the sea. West of the hills, and in the Susquehanna Valley, the quantity of rain falling is much less, only about 38 inches."

The first range of hills referred to by Mr. Blodget are those in which the Perkiomen and its branches take their rise, and in this connection it may be stated as a fact that freshets on this stream are more frequent, and higher in proportion to the drainage area, than on the upper Schuylkill.

Quantity of water required for consumption in the month of July, based upon the rainfall of the year 1858, *augmented by* $\frac{1}{6}$ *for the Perkiomen, as per table, and increased from the average daily consumption by* 120 *per cent., being the assumed percentage for that month.*

NAME OF STREAM.	Average daily consumption.—Million gallons.	Quantity for consumption to be carried by the aqueduct.—Million gallons.	Total quantities.—Million gallons.	Diameter of aqueduct and increased in size for each stream taken in.—Feet.	Capacity of aqueduct running full.—Million gallons.	Velocity per second.—Feet.
West branch (Perkiomen),	60	72·1	72·1	8·000	73,244	2·25600
Great Swamp Creek, .	28	33·6	105·7	9·625	106,177	2·25800
Ridge Valley, .	8	9·6	115·3	10·042	115,545	2·25800
East branch, . .	38	45·6	160·9	11·750	158,236	2·25800
Indian Run, . .	5	6·0	166·9	11·917	163,475	2·26800
Skippack Creek, . .	18	21·6	188·5	12·750	185,491	2·25388
Towamencin Creek,	8	9·6	198·1	13·184	195,000	2·25388
	165	198·1				

This table has been computed for the velocity, from the formula of Robert K. Martin, C. E., and used by him for the air-line conduit 12 feet diameter, for the permanent water supply of the city of Baltimore from the Great Gunpowder Falls. This work is a tunnel 36,495 feet long, from the dam on the Gunpowder River to an artificial reser-

voir (Lake Montebello, near Baltimore), having a storage capacity of 600 million gallons, and elevated above mean tide 163 feet.

Mr. Martin's formula is:

$$V = \sqrt{\frac{180 \times H \times D}{l}}$$

$$= \sqrt{\frac{2\,g\,H}{0{\cdot}007454\frac{l}{r}}}$$

in which H = head, in feet
D = diameter, in inches
l = length, in feet
$r = \frac{d}{4}$

The diameters given in the above table are for a conduit running full. For the Perkiomen, another form is preferred, which will admit of a maximum flow limited to a surface sufficiently below the crown of the arch; 17½ miles to be of the full capacity for maximum delivery (about 12 feet wide by 13 feet in height), the remainder varying to meet requirements, beginning with 8 feet width and height.

Swamp Creek, rising in Berks county, near Boyertown, and flowing into the Perkiomen below the village of Zieglerville, has not been been included in the general plan, because many years must elapse before it will be needed, but it can be utilized whenever required, and its waters brought into the main storage lake near Green Lane by means of a branch conduit. Its drainage area above the height of the Green Lane lake is about 30 square miles.

Advantages of the Proposed Plan.

Some of the advantages of this plan will appear from the following considerations:

First. It will supply, from one point alone, a greater quantity of water than is now required for the present population of the city. Second. It will deliver the water to a basin at an elevation of 27 feet above Belmont, 72 feet above Wentz's Farm, 69 feet above the proposed reservoir at Thirtieth and Cambria streets, 104 feet above East Park, 119 feet above Schuylkill and Corinthian, 125 feet above Delaware and 145 feet above the Fairmount basins. Third. It can supply Roxborough and Mount Airy basins by a pumping station at the aqueduct where it passes not far from the former, and save more than

200 feet in the lift encountered at the present Roxborongh pumping works, beside permitting them to be discontinued, and the long line of pipes in the pumping main taken up and utilized elsewhere. Fourth. It can supply a basin, which may be provided for the service of Manayunk, by a pipe line or branch conduit, tapping the aqueduct line in the Wissahickon Valley, and obviate the necessity for a supply, as at present, from the Roxborough reservoir. Fifth. It will obviate the necessity for all the present steam-pumping stations with their expensive and, in some cases, troublesome monster pumps, and leave Fairmount and its water power, when disconnected from the basins, to be run moderately in the summer, to feed lakes and fountains in the Park or for flushing main sewers.

It remains now only to say that the correctness of my statements as to the route for the aqueduct and the capacity and availability of the water sheds are subjects for investigation by submission to instrumental examinations by competent parties in the field, and when this is done, the cost, to which I have not referred, may be estimated very closely. The work, as far as possible, should be monumental in its character, and whilst no money need be spent for mere show or unnecessary ornamentation, yet nothing should be left undone that may contribute in the least degree to strength and durability. In the tunnels we shall have the everlasting rocks; along the slopes rock cuttings, and over streams and valleys permanent structures of stone or iron. The impounding dams must be of undoubted strength, as they certainly may be if founded upon the rock and built of solid impermeable materials, and so on with all other parts.

The cost of the work would not be so large as that of the Croton Aqueduct—40½ miles long—which cost originally $8,575,000; but as the completion for a full capacity of aqueduct will not be required for many years, neither will the full expenditure. The cost, whatever it may be, can be spread over several years, and will not be so much of a burden that it cannot be borne by a people who steadily look forward to the time when the city of Philadelphia will embrace within its limits a population of two million souls.

Perkiomen Creek above Green Lane.

	Rainfall at Philadelphia in 1858.	Rainfall on Perkiomen, estimated one-fifth greater.	Percentage of the rainfall collectable in each month.	Inches of rainfall collectable.	Millions of gallons collectable from 73 sq. miles.	Inches of evaporation from reservoirs per month.	Evaporation in millions of gallons.	Waste and loss from all sources.—Million gallons.	Percentage of consumption per month.	Consumption at an average of 60 million gallons per day.—Million gallons.	Total demand from reservoir.—Million gallons.	Surplus.—Million gallons.	Deficiency. — Million gallons.
January, . .	2·60	3·12	90	2·81	3,564	1·15	17	12	82	1,525	1,554	2,010	
February, . .	2·29	2·75	80	2·20	2,791	1·65	24	12	83	1,394	1,430	1,361	
March, . .	1·09	1·31	70	0·92	1,167	0·82	11	12	85	1,581	1,604	.....	
April, . .	4·64	5·57	60	3·34	4,237	2·07	30	12	94	1,692	1,734	2,503	
May, . . .	5·01	6·01	50	3·00	3,806	1·62	24	12	105	1,953	1,988	1,818	
June, . .	4·50	5·40	40	2·16	2,740	7·10	105	12	115	2,070	2,187	553	
July, . . .	1·35	1·62	30	0·49	622	6·75	100	12	120	2,232	2,344	.....	1722
August, . .	4·94	5·93	20	1·19	1,510	7·79	117	12	115	2,139	2,268	.....	758
September, . .	1·49	1·79	40	0·72	913	5·41	87	12	109	1,962	2,061	.....	1148
October, . .	1·83	2·21	60	1·33	1,687	7·40	109	12	104	1,934	2,055	.....	368
November, . .	5·62	6·74	80	5·39	6,838	3·95	58	12	100	1,800	1,870	4,968	
December, . .	4·50	5·40	90	4·86	6,166	3·66	54	12	88	1,637	1,703	4,463	
Aggregates & Averages, ...		47·85	59⅛	28·41	36,041	49·37	736	144	100	21,919	22,798	17,676	3996

Aggregates and Averages for all the Streams, based upon the drainage areas which may be utilized for the supply of the Aqueduct.

Names of Streams.	Drainage areas.—Square miles.	Rainfall at Philadelphia in 1858.	Rainfall on Perkiomen, ⅓ greater.	Percentage of the rainfall collectable per annum.	Inches of rainfall collectable per annum.	Million gallons collectable from drainage area.	Inches of evaporation from reservoir per annum.	Evaporation.—Million gallons per annum.	Waste and loss from all causes, per annum.	Consumption, daily average.—Million gallons.	Annual consumption.—Million gallons.	Total demand from reservoirs.—Million gallons.	Surplus.—Million gallons.	Deficiency.—Million gallons.
Perkiomen (Green Lane),	73·	39·85	47·85	59⅛	28·41	36,041	49·37	736	144	60	21,919	22,798	17,676	3,996
GreatSwampCreek,	34·5	39·85	48·85	59⅛	28·41	17,053	49·37	308	120	28	10,228	10,656	8,432	1,832
Ridge Valley,	9·64	39·85	47·85	59⅛	28·41	4,751	49·37	99	72	8	2,913	3,084	2,301	560
East branch,	46·	39·85	47·85	59⅛	28·41	22,735	49·37	465	120	38	13,893	14,478	11,120	2,530
Indian Run,	6·	39·85	47·85	59⅛	28·41	2,959	49·37	65	60	5	1,836	1,961	1,395	365
Skippack Creek,	21·5	39·85	47·85	59⅛	28·41	10,645	49·37	207	96	18	6,577	6,870	5,142	1,215
Towamencin,	10·5	39·85	47·85	59⅛	28·41	5,193	49·37	104	84	8	2,912	3,090	2,645	592
Totals,	201·14	39·85	47·85	59⅛	28·41	99,377	49·37	1,984	696	165	60,278	62,937	48,711	11,090

In this connection there is now one other matter that deserves the most serious consideration, and which should be an incentive to early action by the people. It is this, that long before the population shall have reached the figure named, the waters of the Schuylkill will have become so contaminated by sewage, in consequence of the great increase in population along its banks, as to be totally unfit for domestic purposes; even the next decade may produce a marked change, hence there is no time to be lost in determining the course that should be adopted to secure pure water for domestic as well as for manufacturing purposes. Much time must necessarily elapse, in any event, before a work adapted to the wants of the city can be brought into use. All the Delaware schemes are too costly, as was shown by the commission in 1875, and require no further consideration.

So, after all that has been said and written upon the subject of the water supply for the future, if not notably for the present, there is no other stream, in my judgment, of equal purity with the Perkiomen within reasonable distance from which an adeequate, pure and never-failing supply can be brought; and in closing this paper I must remark that I very cheerfully resign to Mr. H. P. M. Birkinbine the credit of pointing out that stream, and for myself only claim the plan of tapping it at a higher and more favorable point and intercepting and utilizing the headwaters of its principal branches, which fortunately lie in the track and cross a direct aqueduct line to the city over high ground.

On Artificial Atropia.—As is known, atropia on treatment with barium hydrate is decomposed into tropine and tropaic acid, according to the reaction: $C_{17}H_{23}NO_3+H_2O=C_8H_{15}NO+C_9H_{10}O_3$.

The first, and perhaps most important step in the synthesis of atropia, is the re-combination of these decomposition products to form the alkaloid again. This Ladenburg has just accomplished by treating the tropate of tropin with dilute hydrochloric acid at 100°. The tropin tropate used was in colorless crystals and gave no reaction for atropia, even when in 15 per cent. solution showing no action upon the eye. After the treatment for some time with an excess of dilute hydrochloric acid, an oil separated out, which, when purified, solidified to a mass of colorless needles. The author was unable to find any difference between the artificial atropia so prepared and the purest natural product.—*Ber. der Chem. Ges.*

MAP

SHOWING

The Line of the Proposed

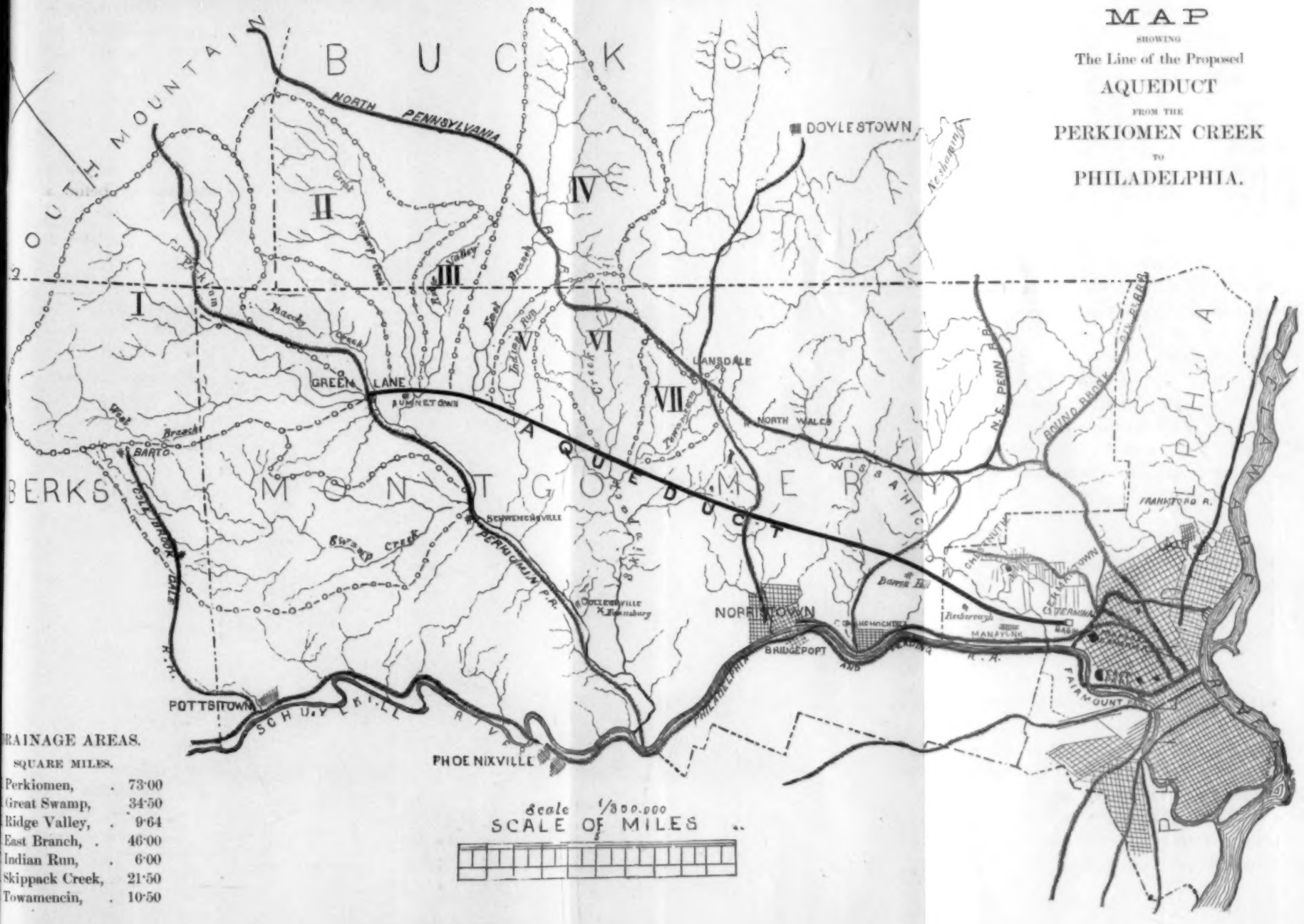
AQUEDUCT

FROM THE

PERKIOMEN CREEK

TO

PHILADELPHIA.



Scale 1/300,000

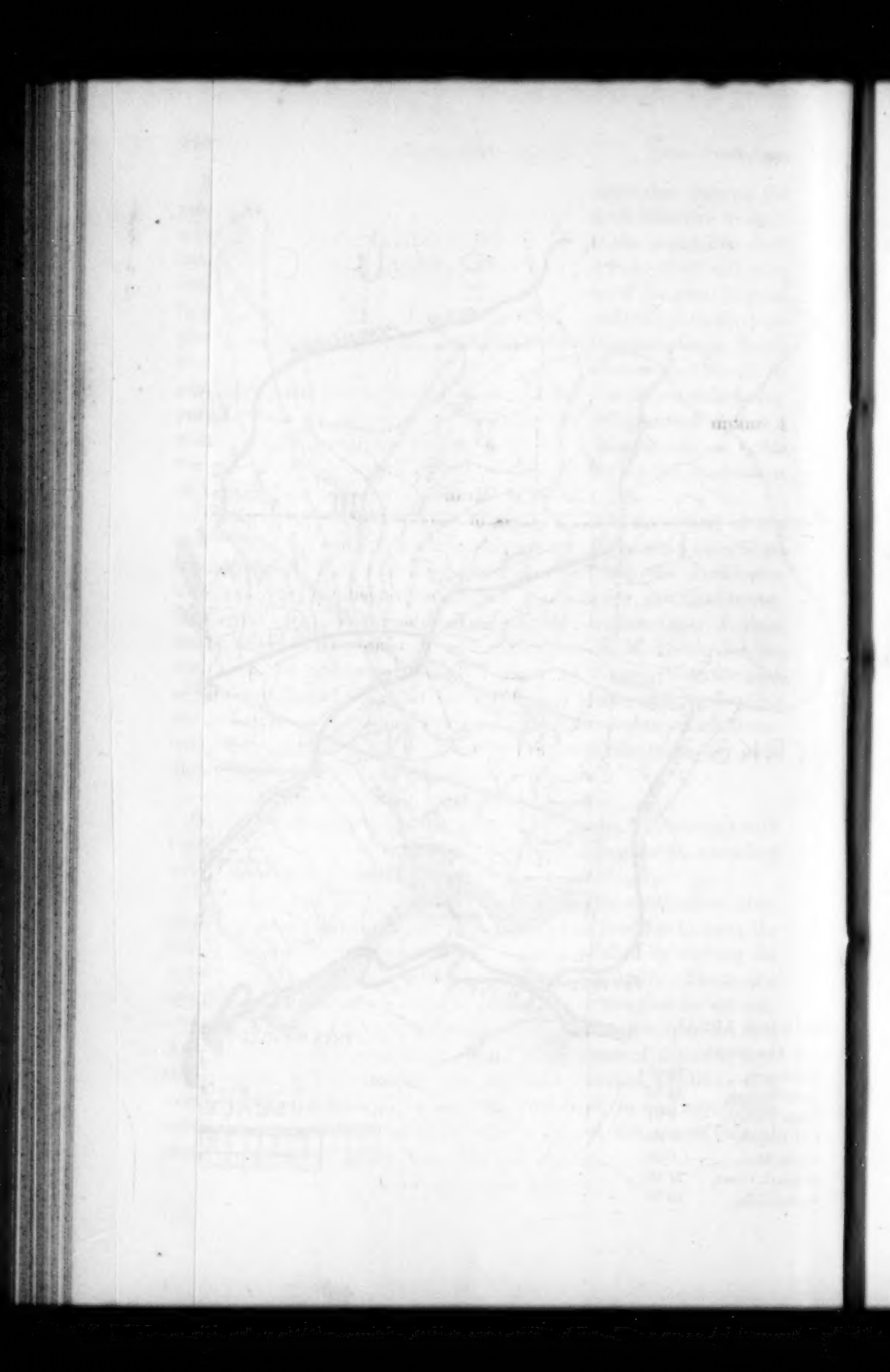
SCALE OF MILES

0 5

DRAINAGE AREAS.

SQUARE MILES.

Perkiomen,	73·00
Great Swamp,	34·50
Ridge Valley,	9·64
East Branch,	46·00
Indian Run,	6·00
Skippack Creek,	21·50
Towamencin,	10·50



HELIOGRAPHY, OR PHOTOGRAPHY IN THE PRINTING PRESS.

GENERAL LIBRARY University of MICHIGAN

By JOHN CARBUTT.

Read before the Franklin Institute at its meeting Sept. 17th, 1879.

The Secretary having desired me to describe to the members of the Franklin Institute how photographs in printing ink are made; before doing so permit me to read from an article prepared by me a short time since for one of our journals—"The Photographic Rays of Light."

In 1796 Alois Senefelder, of Munich, a musician and composer, was in the habit of using pieces of slate of limestone, on which to arrange his compositions before putting them on paper.

While so engaged he wrote with pencil, on a piece of this stone, a memorandum for his mother. Accidentally it fell into a vessel containing greasy water; to his astonishment he saw that every letter had become coated with grease contained in the water, and without affecting the other parts of the stone. This simple accident led him to the discovery of lithography, and little did he dream at that time of the marvelous results now obtained through the means of his invention, or that a chemically prepared surface would be discovered on which, by the action of light, natural objects, portraits and works of design and construction would be drawn, which, when placed in the printing press, would yield, by a process of printing strictly analogous to his own, copies of such objects in permanent pigments.

In 1839 Mungo Ponton, of England, discovered that when paper coated with a solution of bichromate of potassium, and after drying was exposed to light under a drawing, that it received an image, of a brown color, to preserve which it was only necessary to wash the paper in water to remove the bichromate not acted upon by the light. This, as far as known, is the first instance of a picture having been produced by the action of light on a body impregnated with a bichromate salt.

In 1854 Paul Pretsch made known his discovery that a film of gelatine and bichromate of potassium, after exposure under a drawing or other design to light, and after damping with water, would receive ink from a roller passed over its surface where the light had acted upon it, and refuse it where the light had not acted, owing to those parts hav-

ing absorbed water, thus producing a printing surface strictly analogous to the drawing made by Senefelder on the lithographic stone; but Pretsch only used these inkable images to obtain a transfer to be laid down on stone to be printed from.

In 1855 Louis Poitevin made further advance in the use of a bichromatized gelatine film, by producing pictures in half-tone, but nothing of a really practical nature was accomplished by him at that time, as the films would bear but a few impressions to be taken from them.

In 1865 Tessie du Motay, of Metz, France, made still further progress in half-tone printing from a gelatine surface, making use of copper plates as a support for the gelatine film, and from which seventy to eighty impressions could be obtained. The results were considered so good at that time that soon other experimenters took up the subject. Notably to Albert, and Obernetter, of Munich; Rye, of Denmark; Gemoser, of Berlin; Despaqui, of Paris, and Edwards, of London, is due great credit for the perfection to which heliography, light-drawing on a bichromatized gelatine surface, has been brought.

Before describing the making of and printing from a heliograph plate I will briefly explain the similarity between a drawing by hand on a lithograph stone and a drawing by light on a bichromatized gelatine film.

To produce a design upon stone the artist makes use of a crayon or ink composed of materials of a fatty nature, on completion of which, if the stone is sponged with water, it will be seen that the water recedes from that portion covered by the design, but is readily absorbed by the stone outside of the design. On passing over it a roller charged with lithograpic ink it will be seen to deposit on the drawing but not on that part of the stone yet moist from the water, the greasy nature of the drawing attracting the ink while the water repels it.

If a bichromatized gelatine film be exposed to light under a negative the result will be an image or drawing, of a brown color; on placing the plate supporting this film in water it will be seen that where the light has had full action so as to reduce all the bichromate it refuses to absorb water, and where the light has not acted it absorbs water freely and swells up. On blotting off the surplus water, and passing over it a roller charged with lithographic ink, it will be seen to deposit on the parts acted on by light, but refuses to deposit on the parts that have absorbed water, thus establishing the relation analogous to a drawing on stone as regards its acceptance or rejection of a

greasy ink when in a moist condition. This is the relation produced by Pretsch's discovery in 1854, who, like Senefelder, never dreamt of the wonderful results now being daily accomplished by the aid of the camera and printing press. The drawing produced by light, first through the aid of the camera and then by the negative thus obtained on the bichromatized gelatine plate, has a far greater intrinsic value than a drawing produced by the hand of man, be it ever so skillfully executed; for what can exceed the faithfulness with which photography pictures everything placed before the camera? Is not the drawing executed by nature's self?

Heliography—"sun-drawing"—then, is a process by which a picture is produced by light on a chemically prepared surface from which by mechanical means prints in permanent ink can be produced with a celerity and cheapness, delicacy of texture, exquisite gradation, and faithful rendering of detail, that when limited numbers are required will give heliographic productions the preference over other processes of the sister arts.

I will now describe to you how the gelatine printing surface is produced. The support for the gelatine may be of zinc, copper, stone or glass; the latter, being best adapted to the purpose, is most generally used. To secure the gelatine film to the glass, so as to allow of a large number of impressions being pulled, it was found necessary to first coat the glass with a thin substratum of gelatine, albumen and bichromate of potassium; albumen and bichromate; or albumen and silicate of soda; one or other of these preparations is essential to the production of a good printing plate; all are patented, and the patents for these and other improvements are owned by a company in New York known as the Artotype Company, who grant licenses for working them. I hold the exclusive right for photo-mechanical printing for Philadelphia and 25 miles radius.

If one of the first two formulas for a first or cement coating is used, the plate after drying is placed, face down, on a board covered with a black cloth or velvet, and the light allowed to act through the glass for a time sufficient to cause that side of the coating next the glass to have become insoluble; it is then carefully coated with a solution of fine gelatine, containing 15 to 20 per cent. of bichromate of potassium or ammonium, placed in the drying box, which is a rectangular one having cross bars, supplied with screws, on which the glass plates have previously been brought to an accurate level; and dried at a tempera-

ture varying from 110° to 130° Fahr. When dry the plate is ready for exposure under a negative; the usual printing frame used by photographers is made use of, but as we cannot examine the progress of the light's action as in photograph printing, the back of the printing frame is dispensed with, the plate being held in close contact with the negative by wedges placed under the cross bars, and we examine the progress of printing through the back of the plate. When all the detail of the image is visible, the plate is removed from the printing frame and placed in cold water, which dissolves out the bichromate not reduced by light. When sufficiently freed of the now useless bichromate it is allowed to dry. Before putting it on the press the plate is placed for a few minutes in a pan of water. It is then freed from water on the back, placed on the bed of a lithograph press, the surface carefully sponged, and dried with a soft cloth or other means. At this stage a faint image only is visible, and on passing over it a roller charged with a stiff ink those parts answering to the transparent parts in the negative will take ink with considerable freedom, while those parts answering to the half-shades will take much less, and where no light has acted will refuse ink entirely, from the film having so freely in those parts absorbed water. The printer now takes a roller similar in composition to those used in type printing and charges it with the same or a colored ink, but reduced in stiffness with oil or thin varnish, and with very little on the roller. Passing this roller over the plate it continues the inking up of the image until the faintest detail is made visible. A mask of paper having an opening of the size of the subject on the plate is laid over it, a piece of fine paper laid on, the tympan lowered, and with a light pressure pulled through the press, when, if all the conditions have been properly carried out, a print possessing all the delicacy of a fine photograph, but in a pigment as durable as that of the engravings of old, and with all the minuteness of detail and delicacy of light and shade that photography so faithfully gives us.

Heliographic printing is applicable to any kind of subject that can be photographed, and for publishers and manufacturers offers the best means of producing portraits, landscapes, machinery and all kinds of manufactures; reproduction of engravings, paintings and original drawings, old manuscripts, etc., and for illustrating art and manufacturers' catalogues.

Artotypes are executed in any of the permanent printer's inks, and

at much less cost than photographs. To produce the best results special negatives are required to produce the printing plate, and care and skill is required of the printer. The Artotype specimens exhibited before you to-night will, I think, convey some idea of the practical application of heliography.

COLOR-BLINDNESS IN RAILWAY EMPLOYEES.

The evidence furnished by recent examinations of railway men discloses the fact that color-blindness exists to an extent scarcely suspected a few years ago. In all cases where there is direct conflict of evidence as to the state of the signals it would be at least advisable to have the witnesses tested for color-blindness. Dr. Keyser, of the Wills Eye Hospital, Philadelphia, has recently examined a number of railway employees engaged on the systems centering in that city, and according to his report to the State Medical Society, 3½ per cent. of the whole number mistook colors, and 8½ per cent. additional were unable to distinguish accurately the shades of colors. The mistaking of colors was doubtless due in large part to defective vision; blunders in shading are probably due to lack of training. The condition of the eyes was carefully examined with the ophthalmoscope, and of the number under examination 79 per cent. were found of perfect vision and 21 per cent. defective; of the color-blind, 47 per cent. were of perfect vision and 53 per cent. defective; of those who only shaded badly, 77 per cent. were of perfect vision and 23 per cent. defective. Of those found defective, 50 per cent. were green blind, 44 red and 6 blue. Of the 8½ per cent. defective in shading, 95 per cent. were so in greens and 5 per cent. in red. Two men who could not distinguish red from green on tests, had educated themselves to know that red was an intense color, and thus distinguished bright red signals, but at the same time bright greens and other bright colors were red to them. For these they would stop their trains, and so err on the safe side. On the other hand, dark reds, dark greens, and browns were all one to them, thus making those colors useless as signals. Another peculiarity in one case was the ability to distinguish bright red close by, but not at a distance. A color correctly recognized as bright red at three feet was invariably called green at ten feet and beyond. The test methods employed were those of Prof. Holmgren, Dr. Stilling and others.—*English Mechanic.*

STEAM-BOILER EXPLOSIONS.

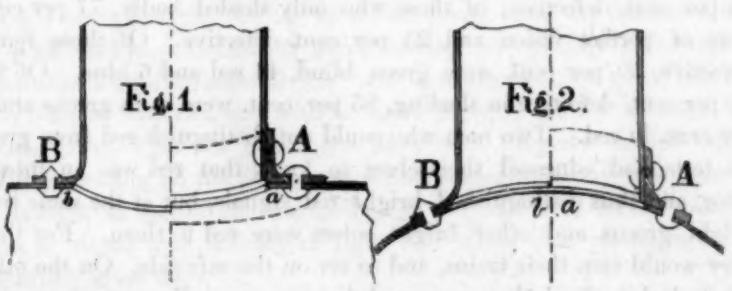
By JOHN W. NYSTROM.

Read before the Franklin Institute at its meeting Sept. 17th, 1879.

The steam-boiler explosion at the mill of Wilt & Son, Philadelphia, on June 29th last, has caused some controversy among engineers and in the daily papers about its cause, and also as to the strength and weakness of steam boilers in general; and in discussing the subject with the Secretary of the Institute, he invited me to explain my ideas of the same at the September meeting. The accompanying illustrations are prepared to show the principal cause of the majority of steam-boiler explosions, namely, the construction of the joints of necks and steam-drums to the main shell of the boiler.

Experiments were made in England some years ago to find the weakest point of steam boilers, and it was found that where the main shells of cylindrical boilers were cut for man-holes, neck or steam-drums, these parts were the weakest and gave way first under excessive pressure.

The Wilt & Son steam boiler burst at the necks between the main shell and steam-drum, which were the weakest points.



The accompanying illustrations represent a longitudinal section, Fig. 1, and a cross-section, Fig. 2, of parts of a boiler and neck, showing two different modes, *A* and *B*, of connecting a neck or drum with the main shell. The strongest joint is that represented at *A*, namely, to bend an angle-iron to fit the joint and rivet the same to the neck and shell. A double row of rivets in the shell would be better. The

angle-iron should be welded to form a solid ring. The ordinary mode of connection is represented at *B*, namely, to flange the neck and rivet the same to the shell with one row of rivets, which is now generally done in all boilers with necks or steam-drums; but the strength of this joint is very deceptive, being only a small fraction of that of the shell without the hole, whilst the joint *A* can be made fully as strong as the shell.

I have spoken to several boiler makers about the angle-iron joint, *A*, but they do not seem to appreciate its value, nor do they apprehend the weakness of the joint *B*. Mr. Longstreth, of the Baldwin locomotive works, objects to the joint *A* on the ground, he says, that "angle-iron is generally made of very poor iron." This objection can be overcome simply by ordering angle-iron of the best quality of iron or of cast-steel. Mr. Le Van says, "the angle-iron joint requires two rows of rivets, two seams for caulking, and it is very difficult to weld an angle-iron ring." Others say "It is not practical."

The steam-force which should be resisted by the portion of the shell cut away for the hole is wholly thrown upon the shell at *a*, *b*, for there is very little strength in the curved portion of the flange at *B*, whilst in the joint *A* that force is wholly resisted by the angle-iron, which has plenty of metal in the points most strained.

For the joint *B*, the hole in the shell is generally cut much larger in diameter than that of the inside of the neck, which weakens the shell more than necessary, whilst for the joint *A* the hole is cut equal to that of the neck.

In the Wilt & Son's exploded boiler there were several cracks in the shell radiating from the hole cut for the necks, which proves the greater strain that portion of the boiler had to sustain. These cracks leaked several days before the explosion occurred, and thus indicated the approach of the accident. Explosions are frequently indicated in the same way, and it is explained in "Pocket-Book of Mechanics," page 436, and also in my work on "Steam Engineering," page 87. If these rules were more respected by engineers many boiler explosions could be avoided.

A letter from New York, published in Philadelphia papers August 28th, says: "An explosion occurred this morning on board the steamer *Essex*. The explosion was a mystery. The steam-drum was blown completely off." The mystery was probably the flanged joint *B*. A

similar explosion occurred on the excursion steamer *Alaska*, near the mouth of Detroit River, September 5th, by which many lives were lost.

The two new boilers made for Wilt & Son are constructed upon nearly the same principle as that of the exploded one, which had three necks, 12 inches diameter, connecting the first steam-drum with the main shell, and two necks between the first and second steam-drums. The two new boilers have each two necks 16 inches in diameter, with 18 inch holes in the shell.

Suppose the steam pressure in the boiler to be 100 pounds to the square inch, the force on the joint *B* will then be 201·06 × 100 = 20,106 pounds, or nearly 10 tons to be borne by 30 rivets of eleven-sixteenth of an inch in diameter, or 670·2 pounds the tensile strain on each rivet, or 1800 pounds to the square inch. If this force was applied evenly on the rivets the danger would not be so great, but the treachery of the joint *B* is that the greatest part of that force acts on one side of the rivets.

The diameter of the shell is about 54 inches, and 54 × 18 × 100 × $\frac{1}{2}$ = 48,600 pounds, the shearing force acting on 14 rivets, or 3471·4 pounds on each rivet in the flange. The force, 48,000 pounds, is acting on the shell and flange at *b b'*, where there is acting the additional force of the usual steam pressure in the boiler, namely, 54 × 100 × $\frac{1}{2}$ × $\frac{5}{16}$ = 8640 pounds per square inch of section of the shell.

The joint *B* is therefore the weakest part of the boiler, and is the principal cause of explosions of this class of boilers.

It is an overlooked fact that the quality of workmanship in the neck-joint *B* is generally inferior to that of the rest of the boiler. The height of the conical riveted heads in the shell varies between $\frac{7}{16}$ and $\frac{9}{16}$ of an inch, whilst in the neck-joints that height is generally only $\frac{4}{16}$ to $\frac{5}{16}$, and very often less.

The principal strain on the rivets in the shell is a shearing force, whilst the rivets in the neck-joints not only sustain the same or greater shearing force but also a tensile strain, and therefore the riveted heads in the neck ought to be much stronger than those in the main shell.

I beg to be distinctly understood that the remarks here made are not intended to apply specially to the new boilers at the mill of Wilt & Son, but to that class of boilers in general.

I have lately been entrusted with the inspection of a new set of similar boilers constructed by Mr. Le Van for Mr. George Campbell, at Twenty-first and Washington avenue, and in my report upon the

same laid great stress upon the weakness of the neck-joints, which was fully appreciated by Mr. Campbell, who ordered the necks to be altered to cast-steel plates of half an inch thick, instead of five-sixteenths, in the first necks. This alteration would increase considerably the strength and safety of those boilers; but, unfortunately, the Hartford boiler inspectors object to that thickness on the ground, they say, that "the boilers will be too rigid," probably for difference of shrinkage in the main-shell and steam-drum. The necks are, however, sometimes made of cast-iron, which is still more rigid. The French, Richards & Co.'s boilers, at Tenth and Market streets, also two boilers at Crown and Callowhill streets, have cast-iron necks one inch thick, and are all insured by the Hartford company, but they will not insure boilers with cast steel necks half an inch thick.

The accompanying illustrations, Figs. 3 and 4, represent the boilers in question, but they are not always set as here shown. The water-line is generally kept in the steam-drum at v, but in the Campbell, and also in the new Wilt boilers, the water-line is kept at W in the main boiler.

FIG. 3.

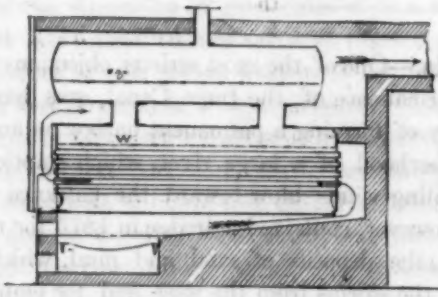
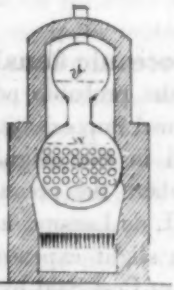


FIG. 4.



It has been explained that the weakest points in this class of boilers are in the necks, and the force acting to separate the drum and shell is say $F = 40{,}000$ pounds on the two necks. Suppose the weight of the drum half full of water to be $W = 3000$ pounds. When the neck-joints give way and the boiler explodes, all the water in the boiler and drum is instantly formed into a dense foam of the initial steam pressure; and suppose the force F to act for a time of only $T = \frac{1}{2}$ second. The velocity with which the steam-drum will be thrown upwards will then be

$$V = \frac{gFT}{W} = \frac{32{\cdot}17 \times 40{,}000}{3000 \times 2} = 214{\cdot}4 \text{ feet per second.}$$

The height to which the drum will be thrown vertically will be—

$$H = \frac{V^2}{2g} = \frac{214{\cdot}4^2}{64{\cdot}34} = 720 \text{ feet.}$$

It is well known that steam-drums are thrown to great heights and distances by the explosion of this kind of boiler, to which may be referred the following cases at the establishments of I. P. Morris & Co., Philadelphia, 1862; Cornelius & Baker, Philadelphia, 1864; Jessup & Moore, Wilmington, 1871, and Wilt & Son, Philadelphia, 1879. In all these, and in a great many other cases, the boilers exploded on account of weakness of the neck-joints.

The efficiency of boilers of this kind is very deceptive. They apparently evaporate much water, but the steam produced by them is generally very wet, for want of proper circulation of the boiling water, and they are therefore not economical boilers in the consumption of fuel. A thorough scientific investigation of the operation of this kind of boiler would probably make important revelations.

Interoceanic Canals.—One of the most serious objections urged against the probable permanence of the Suez Canal, was based on the assumed impossibility of forming a permanent harbor on an open coast and in the neighborhood of a large river, which emptied in a region where the prevailing winds blow toward the entrance of the canal. M. de Lesseps, however, contrived a dredge in 1875 for removing, at a slight expense, the deposits of sand and mud, which were brought to Port Said by the storms from the west, and for employing them in extending and strengthening the jetties. The results have justified all his anticipations; the deposits have ceased altogether in many places, and the labor of clearing the channel, after the winter storms, has been greatly reduced. M. de Lesseps is now endeavoring to secure an early commencement of the Nicaragua Canal. He says: "In my opinion, it is certain that this useful work will be finished before the end of the nineteenth century, a century which began in war and which will close, thanks to the progress of science, by the pacific opening of new communications among all the nations of the globe."—*Comptes Rendus.* C.

NOTE ON THE CHANGES PRODUCED BY FATTY MATTER IN THE WROUGHT AND CAST IRON PARTS OF ENGINES EXPOSED TO THE ACTION OF STEAM.

By M. A. MERCIER,

Chief of the Experimental Laboratory of the Railway Company P. L. M.

Translated from the *Annales des Mines* for 1879, page 234, by Chief Engineer ISHERWOOD, U. S. Navy.

I have had, on different occasions, to examine in the laboratory some balls, more or less hard, that were taken, from time to time, from the cylinders of steam engines, and which were generally attributed to the use of acid lubricating oil.

These balls, when crushed and digested in ether, left an insoluble residue of peroxide of iron, whilst the soluble part was composed of oleic acid combined with the oxide of iron and mixed with a non-decomposed oil.

Does the formation of this oleate of iron result from the use of oil more or less rancid, having an acid reaction; or, more probable, is it the product of the decomposition of neutral fatty matter in presence of iron and of steam at a high pressure? This alternative caused me to make the following experiment in the laboratory:—

Steam of near the atmospheric pressure was admitted to a closed vessel filled with wrought iron chippings immersed in oil of colza rendered neutral by a previous treatment with carbonate of soda. A gas pipe, dipping into a gauge filled with water, was placed in connection with the closed vessel. The apparatus being purged of air by the steam, I saw small bubbles of gas, which I recognized as hydrogen, disengage—slowly, it is true, but continuously. The same experiment repeated, with wrought iron chippings perfectly free of grease, gave no disengagement of combustible gas.

According to these experiments, and contrary to some explanations given of the changes produced in the metals by fatty matters, the latter have no need of being acid or rancid, nor of being heated above 212°F., to decompose steam in presence of iron and thus produce oleate of iron, glycerine and hydrogen.

On an examination of the cylinders of the agglomerating engine at

Brassac, after use with an addition of carbonate of soda to the feed-water (which water contained 31·91 grains of sulphate of lime per 1¾ pints), the spaces in the piston were found filled with hard matter, formed of grease mixed with oleate of lime and with carbonate of lime, brought in the water, foamed or primed over with the steam. No iron was found; the carbonate of lime had preserved the metal from any change.

The face of the steam-valve of the stationary engine at Valence showed corrosion more or less deep, whilst the valve-stem remained intact. There could be detached from the corroded parts a hard matter which softened at about 392°F., but did not in the least melt. This kind of mastic enclosed particles of iron rubbed off by friction, and had the following composition:

Oil, not changed,	2·60
Peroxide of iron,	91·55
Oleic acid,	5·60
Loss,	0·25
	100·00

In this engine there had been no foaming or priming over of lime, which might have, as in the preceding case, preserved the iron from change.

In the stationary engine of the workshops at Paris the same fact occurred. The lubricating oil of the inclined valves collected at the lowest part of the valve-chest and perforated the cast iron.

In the locomotives there was observed the same change in the metal at the tappings for the screws which held the springs of the steam-valve.

These observations led me to make the following experiment: An iron bucket containing wrought iron chippings, thoroughly saturated with oil of colza previously neutralized, was left during eight days in a reservoir supplying steam to several steam hammers. At the expiration of this time there were taken from the bucket about 30½ cubic inches of very thick oil, which flowed with difficulty and emitted an odor similar to what is produced by the action of an acid on iron; the iron was strongly corroded, and the oil—colored to a dark brown and entirely soluble in ether—contained 7 per cent. of the oxide of iron. This oleate of iron oxidized rapidly on contact with air and, like all the minimum salts of iron, gave up some peroxide of iron;

when again placed in contact with iron it attacked the iron and was thus brought back to its first state of saturation. In this manner can be explained the large proportion of non-combined peroxide of iron contained in the matter found on the valve-face of the engine at Valence.

These facts appear to me to clearly explain the corrosions of certain boilers receiving fatty matters brought over from the cylinders by the exhaust steam, or used to lubricate the throttle valve of locomotives.

In locomotives the steam is generally taken from the upper part of the boiler by means of an immersed slide throttle valve; the oil used for lubricating the latter becomes saturated with iron, and being thus made heavier than water sinks to the bottom of the boiler where it attacks the iron plates, forming in them those excavations which are only found when feed-water is used of such purity as not to deposit the lime-scale that in most cases preserves the boilers.

The use of mineral oil, thickened if necessary with wax or paraffine, for the lubrication of moving parts placed in the steam, would be without doubt a good means of preventing changes in the material of such organs.

New Clothing Material.—A Berlin inventor has patented a new kind of cloth, which consists principally or entirely of sponge. The sponges are first thoroughly beaten with a heavy hammer, in order to crush all the mineral and vegetable impurities, so that they can be easily washed out. They are then dried and pared, like a potato, with a sharp knife, the parings being sewed together. The fabric which is thus obtained is free from all the danger which sometimes arises from the absorption of poisonous dyes into the system; it absorbs without checking the perspiration, so as to diminish the danger of taking cold; it is a bad conductor and therefore helps to maintain a uniform surface temperature; it can be more readly cleansed than the ordinary woolen garments; its flexibility diminishes the liability of chafing; the ease with which it can be employed in shoes, stockings, drawers, undershirts, hat linings and other articles of clothing seems likely to make it especially useful as a protection against rheumatic and pulmonary attacks.—*Fortschr. der Zeit.* C.

ZINC VEINS AND WORKS OF LEHIGH VALLEY.

Zinc ore was first discovered in Pennsylvania on the site now occupied by the small village of Friedensville (Village of Peace), in Lehigh county, in 1845. The village stands at the head of the beautiful Saucon Valley, rich in an agricultural sense, and doubly so in minerals—iron and zinc. In 1847 William Theodore Reepper, a resident of Bethlehem, and later Professor of Mineralogy in Lehigh University, from a pure love of science wandered over the spur of the South Mountain, that separates the Saucon Valley from Bethlehem, and was shown by a farmer (Ueberoth) a mineral that had puzzled the local mineralogists to classify. He pronounced it to be "calamine," or native carbonate of zinc. This hap-hazard discovery led to the development of the apparently inexhaustible mines that have for more than a quarter of a century supplied the large works of the Lehigh Zinc Company at this place. The works were erected by Maj. Samuel Wetherill, now of Philadelphia, in 1853, for the production of zinc-oxide, in furnaces, by a process of Maj. Wetherill's invention. The works cost $85,000, and on October 13, 1853, they produced the first zinc-white ever made in America. Maj. Wetherill commenced his experiments as early as 1850, believing that it was possible to substitute the oxide of zinc for white lead for paints. In 1852 he successfully invented his "furnace process." This, combined with the "bag process" of Richard Jones, Esq., made the matter possible. Before completion, the works were blown down by a tornado, but immediately rebuilt, Charles J. Gilbert, Esq., of New York, being Maj. Wetherill's partner. The works had an annual capacity of 2000 tons. Up to 1857, when Messrs. Gilbert & Wetherill sold out to "the Pennsylvania and Lehigh Zinc Company," the product had been 4775 tons of oxide. This company was composed of New York capitalists, with a capital of $1,000,000, and Thomas Andrews, of New York, was the first president. Maj. Wetherill continued in the superintendence of the works until 1857, when he was succeeded by Mr. Joseph Wharton, of Philadelphia. The latter leased the works, and his financial ability and his means and credit floated the concern through the financial storm of 1857. In 1860 the title of the company was changed to the Lehigh Zinc Company, and it is now a strictly Philadelphia company.

These works produced the first *metallic* zinc made in America. Maj. Wetherill had made many experiments looking to the production of metallic zinc, but had been only partially successful. In 1859 Mr. Wharton contracted for the erection of spelter works, and their erection was entrusted to Mr. Louis De Gee, of the firm of De Gee, Gernant et Cie., of Ougree, Belgium, who had been induced to come to the United States for this purpose. These works were put in successful operation, and produced the first metallic zinc in July, 1859. The operatives in this department were at that time imported from Belgium, and importation of Belgian experts and workmen have been frequent since. These spelter works have been in active operation from that time, and during the Franco-Prussian and Turko-Russian war, the European demand upon the works was very large for the manufacture of cartridge cases.

In all that pertains to the original in the application of zinc these works seem to lead. The first sheet zinc, as well as the first spelter, was here made. Under the superintendence of B. C. Webster, Esq., then and since 1863 President of the Company, a mill for the rolling of sheet zinc was erected in 1864 and 1865. Alex. Trippel, who had been sent to Europe to acquaint himself with the production of sheet zinc, had supervision of the erection. The first sheet zinc in America was rolled in these works in April, 1865.

Before describing the mines that supply all these works, and which are a wonder in their way, a brief description of the buildings and the process of manufacture will not be without interest. The old oxide works include about two acres of buildings, furnaces, tower, dry room, bag room and packing houses. The ore for this purpose is ground fine by a stone crusher, and then carefully mixed with coal known as "buckwheat," next in grade to "pea." It is then transferred to the furnaces, of which there are 54, with 1390 feet of grate surface. Within these the mixed coal and ore is reduced by the direct action of heat and the cold-blast upon a furnace bed having a multiplicity of small holes, each producing the reducing-flame of the blow-pipe. The zinc oxide rises, passes through a huge combustion flue to a large circular tower, 50 feet high, in which the oxide and ashes separate. The ashes being heavier than the oxide, the velocity of the fans which impel the product forward lifts the oxide to the top, and the ashes drop to the bottom. The oxide is forced onward through a cooling-room, size 80 by 40 feet, and heated to from 400 to 700 degrees Fahrenheit.

Thence the oxide is blown through large flues into the "bag" room. This is a huge building, devoid of furniture, excepting long bags of muslin, 45 feet long, in which the oxide is deposited. It is now white as snow, and after being kiln-dried and bolted, it is placed in bags, and by heavy pressure reduced in bulk, barreled, and is ready for shipment.

The spelter furnaces cover a space about one-half that occupied by the oxide department, taken up by rooms for storing ore, grinding-rooms, dry-room for retorts, pottery, reverberatory furnaces and spelter furnaces. Of the latter there are thirty-two. The ore, having been ground and mixed with coal, passes through the reverberatory furnaces. In calcinating it changes from a blue blende to a deep yellow. The sides of the furnaces bristle with retorts. These are charged with the calcined blende, the mouth of each being covered with a fire-clay condenser. An intense heat is maintained by fires beneath, and condensation takes place within the cones. The metal is then drawn out into ladles, poured into iron moulds, forming ingots about 1½ inches deep and 7 by 22 inches in size. When cooled the metal is ready for the sheet-mill or the market.

The rolling-mill is a brick structure 103 by 64 feet. The sheets are heated in ordinary annealing furnaces, and are rolled by ordinary two-high sheet rolls. The secret of polishing the plates consists in rolling numbers of them at a time and changing their position in the "pile," the friction doing the work. As early as 1857 Maj. Wetherill had sent some metal to the sheet-iron mills of the Messrs. Wood, which was successfully rolled and showed the malleability of the metal. The polish was wanting. When Maj. Wetherill first saw the simple process by which the metal was polished—and considered how much thought, time, labor and money he had spent in trying to find the secret—he relieved his mind with a cavalry man's expletive and walked away. The sheets are cut into any size desired, and a recent invention enables the company to cut circular plates for stoves, of which there is a large demand. The American sheet zinc supplies not alone the home market now, but much of it is sent abroad. It is fully up to the standard of the popular "La Vieille Montaigne" of France, and because of its freedom from arsenic and iron is often preferred.

The capacity of these works is as follows: For oxide of zinc, 3000 tons per year; for metallic zinc, 3600 tons per year; for sheet zinc about 3000 casks or 1800 tons, or about one-half the annual consump-

tion of the country. From 300 to 500 men are employed by the company, and 40,000 tons of coal are annually consumed.

All this has grown up from Prof. Roepper's discovery in the Saucon Valley, and it is worth while returning to this point. The mines are four miles away from the works, and all the ore is hauled by heavy teams over the rough mountain roads. The consumption of ore taken from these mines has reached the enormous quantity of 19,000 tons in a single year, including rich blende, which has been developed in the progress of mining. The main shaft is 250 feet deep, and the valley is arched and tunnelled and cut away to a great depth and in a perfect network to get at the seams of the veins.

All about are evidences of a violent upheaval in the long ago, and in the crevices between the rocks the calamine or blende is found, with veins of iron ore at times mixed with the zinc veins. The veins are followed under, over and around huge rocks, which are carefully propped up, and the leads are a perfect labyrinth of rocky-begirt aisles, a wonder to behold, and a rare study for the geologist, the metallurgist and the engineer. But the curiosity of the mines is the monster engine—believed to be the largest and most powerful in the world —and, in honor of the efficient President of the Company, happily named "Webster's Unabridged." At an early day, and at a shallow depth, water was encountered in working these mines. It was overcome by a small pump worked by a single-horse power. Later this was followed by a donkey pump, still used for dressed ores. Then, as the mines went downward, came a Burdon engine of 30-horse power. This was followed in 1863 by a Corliss engine of 100-horse power, working a series of centrifugal pumps, which found their limit at a depth of 65 feet, with 1500 gallons of water per minute. But the water came faster than the pumps could remove, and the company decided to make some lasting provision for controlling it, by establishing power to raise 4000 gallons per minute from a depth of 150 feet, if so much should be found, and to this end they erected and started, in 1865, an engine of 32-inch cylinder and nine feet stroke, working two 22-inch lifting pumps, to which a third 22-inch lift was soon added with 17 strokes per minute, and the shaft carried down to 122 feet in 1866, when it encountered and raised 5600 gallons, and there found the limit of its capacity.

Mr. John West, the engineer of the company, had already matured a plan of engine, pumps and shafts, for raising 12,000 gallons per

minute from a depth of *three hundred feet*, and in December, 1868, the company contracted with the Messrs. Merrick, of Philadelphia, for this new engine, and a year later with Messrs. I. P. Morris & Co. for the pumps, boilers and mountings. The timber for shaft and pump-rods was brought from Georgia. This engine and its pumping apparatus were set in motion January 19, 1872, in the presence of a large concourse of people and amid interesting ceremonies. A technical description of the engine is not wanted, but the following particulars will not be uninteresting: The engine has a pumping capacity of 17,000 gallons per minute (and has run to 19,000 per minute in an emergency), raising water from a depth of 350 feet. The engine alone weighs 650 tons, and including the pumps and boilers, the total weight of the machinery is 1000 tons. The cylinder is 110¼ inches in diameter; length of stroke, 10 feet. The heaviest pieces of iron in the engine are the sections of beams, which weigh 24 tons each. The fly-wheels, of which there are two, weigh 75 tons each; crank-pins, 1 ton each. The piston-rod is 14 inches in diameter. The crosshead weighs 8 tons. The connecting-rods have 9-inch necks, are 15 inches in the middle, 41 feet 2½ inches long, and weigh 11 tons each. There are two air-pumps, 50 inches in diameter each. The engine drives four plunger-pumps, each 30 inches in diameter by 10 feet stroke, and four lifting-pumps, each 31½ inches in diameter by 10 feet stroke, the plunger-pumps being uppermost and stationary. The lifting-pumps are in the bottom, and are movable, so as to go down as the shaft is sunk. To handle these pumps a steam capstan capable of lifting 50 tons vertically is used.

The foundation that holds this moving mass of iron—and it moves without a jar—is a marvel. The bob-wall of solid masonry 9 feet thick was commenced on a plat of solid rock 114 feet below the surface. The foundation for the engine is 32 feet deep below the bed-plate. The engine is estimated at 3500 horse power. The engine is conceded to be the largest fixed single engine in the world, that at Harlaem Meer being a compound engine, with one cylinder within the other. She works comfortably at 12 strokes per minute. Altogether, this engine is a marvel of mechanical engineering and mechanical skill, and it has attracted visitors from all sections of the world.

This monster is now standing idle. Recently the company discovered a new vein of blende, which they are now working without any interference from water. This vein is not only very rich, but has

some very peculiar and very desirable characteristics, being available, when worked with brass or copper, for purposes unknown to ordinary zinc—among others, that of making metallic cartridges. The cost of running the large engine was so great that for a time it was feared these works would have to close up. An advantageous contract and the discovery of the new vein have averted this calamity to South Bethlehem. The works occupy ten acres of ground, and their cost has been as follows: Oxide works, $125,000; spelter works, $100,000; rolling mill, $51,000. Total, $276,000.—*Public Ledger.*

ALGERIAN IRON ORES. MINES OF AÏN-SEDMA, NEAR COLLO.

Translated for the JOURNAL.

Results of analyses made at the School of Mines, Paris, Aug. 21, 1876, by Mons. A. Carnot, Engineer of Mines, Director of the Assay Bureau.

	Samples				
	No. 3.	No. 9.	No. 16.	No. 20.	No. 21.
Silica,	5·	2·	2·60	2·	2·30
Alumina,	1·60	.....	.....	trace	trace
Peroxide of iron,	89·60	99·	96·60	98·	98·60
Oxide of manganese,	trace	.....	trace	trace	trace
Lime,	.....	0·30	0·20	.....	trace
Magnesia,	0·15	0·15	.....	.....	.....
Sulphuric acid,	Absent in all the specimens				
Phosphoric acid,	0·10	0·05	trace	0·05	0·05
Loss by calcination,	3·30	.....	.....	.....	.....
Totals,	99·75	101·50	99·40	100·05	100·95
Pure iron,	62·12	68·64	66·98	67·95	68·36

Names of the ores:

No. 3 Ledoux bed (micaceous; "*fer oligiste*").

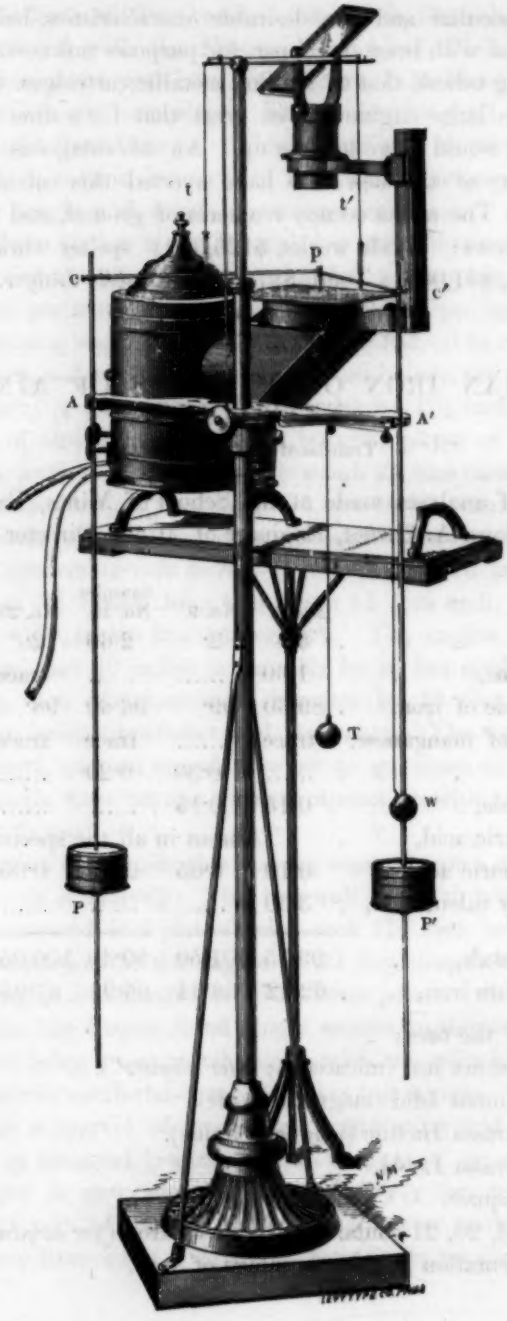
9 Almont Idid (magnetic oxide).

16 Carassa Incline (magnetic oxide).

20 Carassa Level.

21 Laquais.

Nos. 9, 16, 20, 21 contain suboxide of iron (*fer oxydulé*), whence a slight augmentation in the percentage of iron.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QUEEN'S NEW FORM OF TISLEY'S COMPOUND PENDULUM.

The object of this instrument is to trace the elegant curves, corresponding to sonorous vibrations, so well known under the name of Lissajou's figures. With Lissajou's instrument, the figures are only visible while the forks continue to vibrate, and they only give the elementary forms, while the compound pendulum gives us a permanent set of complete tracings, elegant in design and of infinite variety. They can be preserved for years, and studied at leisure.

"This instrument is not limited to certain figures or certain classes of figures. It will trace with equal ease the elegant curves, representing all the musical intervals, and an endless variety of other curious curves, corresponding to the gradual changes between unison and octave, octave and fifth, and generally between the fundamental and its harmonics.

"Besides these changeful phases it may describe others, which have no equivalent in music. In most cases such figures will be extremely complex, but always rigorously symmetrical. By the optical method, the consonance or dissonance, as already stated, is represented by a mere outline; but the compound pendulum, after first tracing this elementary form, fills up the enclosed space with an exact reproduction of the same curve, always in a gradually decreasing scale until the vibrations die away. We have thus a series of curves within curves, which please by their elegant form and marvelous regularity; but the eye, gratified at first, is soon bewildered, and at last is lost in the midst of tbe apparently endless gyratory web."

This very interesting instrument, in the form presented in the figure, is specially adapted for use with the vertical or upright lantern; it consists of two pendulums, PP', which conjointly move the pen. The apparatus is simple and easily worked, the two pendulums, PP', are balanced on knife edges at AA', and continued above their axis of suspension to cc', from which points project two brass arms cp and $c'p$, which, when the pendulums are quiescent, meet at right angles in p. Perfect freedom of motion in every direction is obtained by connecting these with the pendulums by ball and socket joints at cc'. Two threads, tt', are fastened at their upper ends to delicate springs, attached

to the brass arms, $cpc'p$, and at their lower ends to an adjustable screw, d, by means of which the tracing point, p, may be raised and lowered without, in any way, affecting the vibrations of the pendulums.

The brass plates, sliding upon the pendulums, are intended to receive the weights, which can thus be placed at different heights, and the relative rate of vibration of the two pendulums altered. The sum of the weights used should vary from 5 to 12 pounds. W is a weight sliding upon its pendulum, and counterpoised by a weight T. The object of W is to slightly change the rate of vibration while the pendulums are in motion. By this means the pendulums can be adjusted very accurately, or if desired, one can be given a small fraction of a vibration in excess of the other, it can be entirely removed if desired.

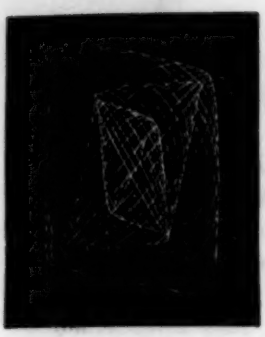
To exhibit these beautiful effects to an audience a plate of glass, blackened by burning camphor, is placed upon the vertical lantern, as shown in the figure, the requisite weights are added to the pendulums and they are set in motion.

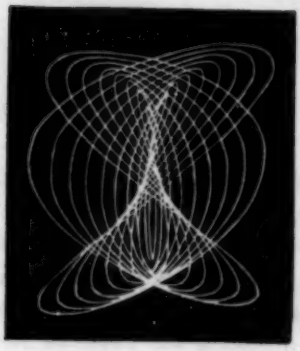
Then, if we want a curve corresponding to an octave, one of the pendulums must make two vibrations while the other makes one. Having ascertained this, we start the pendulums together, then lowering the pen, the beautiful curves will be traced.

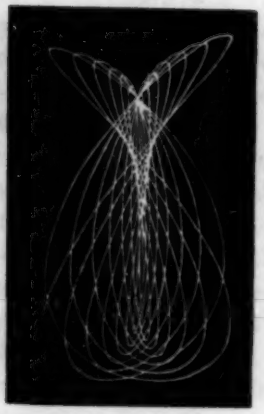
"It is not easy to imagine a more striking experiment than that afforded in the present instance, by the noiseless and gradually decreasing sweep of a pen point gliding over its sinuous path, in obedience to the oscillations of two conjoined pendulous bodies, and tracing, before the eyes of admiring spectators, curves of maze-like intricacy and yet of faultless symmetry. As in music, the simplest harmony is the most agreeable to the ear, so with these figures, the simpler the proportions between the vibrations of the pendulums the more pleasing are the resulting curves."

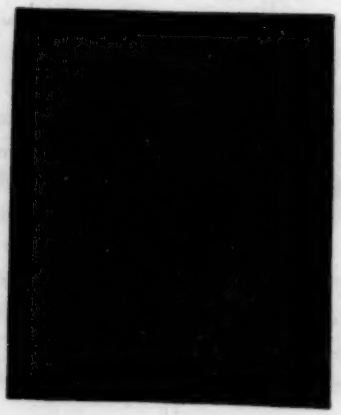
Fac-simile copies of tracings made with the new instrument are given. These beautiful tracings can be preserved for years by simply flowing them with collodion. James W. Queen & Co., of Philadelphia, are the manufacturers of this instrument.

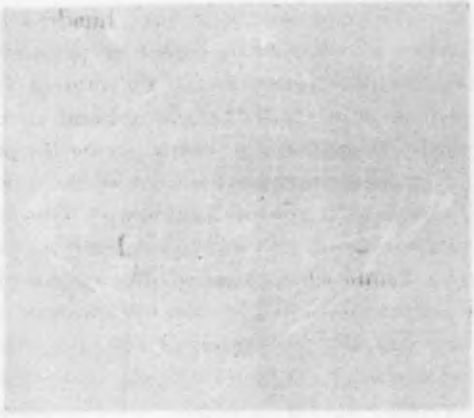
Protection of Iron against Rust.—A varnish composed of 120 parts mercury, 10 parts tin, 20 parts green vitriol, 120 parts water, and 15 parts hydrochloric acid of 1·2 sp. gr. furnishes a good coating for iron that is exposed to the weather.—*Oester. Zeitsch.* C.











AMERICAN CERAMIC CLAYS.

The materials for making every description of fictile ware are found widely distributed in the United States. As early as 1766 American clays were imported into England, captains on their return voyages often taking samples from the Carolinas, Georgia and Florida. Many of these reached Wedgwood, who, in allusion to one of them says: "It will require some peculiar management to avoid the difficulties attending the use of it." These trials turned out well, as we find him making arrangements for a regular supply from Ayor, in the country of the Cherokees, about three hundred miles from Charleston. He desired a monopoly by patent or parliamentary grant, but ultimately sent out an agent. In 1768 a cargo of Carolina clay reached Liverpool, and the trade became general in the Cherokee and Pensacola clays, Wedgwood apparently giving the preference to the latter.

America contributed to Cookworthy's invention of porcelain in 1760. In 1745 an American had shown Cookworthy specimens of kaolin and petuntse found in Virginia, and samples of the ware made from them. It is kaolin which is essential to the success of the manufacture. The final practical effect of Mr. Cookworthy's association with the American was the foundation of the English porcelain industry. The acknowledgment is thus made in the catalogue of the Museum of Practical Geology, London: "The great advance of the porcelain manufacture of England is due to the discovery of kaolin in Cornwall, by William Cookworthy, of Plymouth, about 1755. He apparently had his attention directed to the subject by an American, who showed him samples of china stone and kaolin from Virginia in 1745." One hundred and thirty-two years later the country from which the suggestion came is importing kaolin from that which received it.

The clay of Woodbridge was known before the Revolution; the soldiers at Perth Amboy called it fuller's earth and used it for cleaning their buckskin breeches. In 1800 the South Amboy clay was dug for making stone-ware, and after 1812 the use of New Jersey clays for fire-bricks and other refractory materials began. Soon after 1816 Mr. Price was shipping fire-clay from Woodbridge to Boston, to be used in making fire-bricks. In 1820 Mr. Jacob Felt, of Boston, started a trade in the clay, buying it at 25 cents per ton, which trade was main-

tained for years. The Woodbridge deposit is very rich, and is now extensively worked. It can be used for fire and pipe-clay, and for white ware. In 1855 clay for fifty million fire-bricks was taken from the pits at Woodbridge, Perth Amboy and South Amboy, a large quantity being for fine pottery. In 1868 the production had doubled. In 1874 265,000 tons of fire-clay were dug, and an average price of $3.50 per ton realized $927,000; 20,000 tons of South Amboy stone-ware clay, at $4 per ton, realized $80,000—an evidence of the value of the deposit. The term "kaolin" is frequently applied to the native clay as found, before being separated from its impurities. In a report from the secretary of the United States Pottery Association for 1876 he observes that the clay or kaolin mines of the United States have been wonderfully developed in the past few years. Rich and inexhaustible beds exist in the following States: Delaware, three extensive deposits; Pennsylvania, three very fine mines, which are being worked, and the whole of Chester county abounds with as fine a deposit as England can boast; in Illinois, Missouri and Indiana large and rich deposits are being worked; New Jersey abounds with ball clay and all kinds of fire and retort clays, while Maine, Connecticut and Maryland furnish feldspar in abundance, and Pennsylvania and Maryland have endless quantities of quartz or silica. It may appear singular that the Union Porcelain Works at Greenpoint import kaolin; but, as remarked by Charles de Bussy, the decomposition of feldspar *in situ* does not itself serve for the fabrication of porcelain.—*Jour. of App. Science.*

Economy of the "Compound" Engines.—M. A. Ledieu collates the comparative experiments of Hirn, Leloutre, Hallauer, Dwelshauvers-Dery and Grossetete with the common system and the Woolf or compound system. The comparisons are made with especial reference to the complicated and injurious effects of the heated walls of the cylinders and of the internal changes in the steam pressure. The great skill of the engineers who conducted the experiments gives great value to the results. Ledieu finds ample reason for the great reputation of the compounds among merchants and naval officers in their steadiness of action, their slowness of wear, and their economy of lubrication. Some opponents of the Woolf system lay great stress upon the cost and weight of the machinery, but their objections are soon compensated by the continued economy of fuel and lubrication. *Comptes Rendus.* C.

A PECULIAR SPARK DISCHARGE.

When the electrodes of an induction apparatus consist of a point and a ball or plate, the striking distance of the spark produced is considerably greater if the point form the positive pole and the plate the negative, than if the point be negative and the plate positive. With the latter arrangement, under certain conditions, Herr Hankel (of the Leipsic Society of Sciences) has observed the remarkable fact that from the negative point *positive* electricity may pass over in long sparks to the opposite plate.

To the pole of an induction apparatus, which is positive for the break of the current, a blunt point was attached, and opposite to it was fixed a brass disc 200 mm. in diameter, which, with the negative pole of the inductorium, was connected to the earth. With this arrangement there passed, at an interval of 240 mm., zigzag sparks from the point to the plate, while, with greater intervals, a brush discharge took place from the point. The point being then made the negative pole of the inductorium, by turning the commutator (the primary current having the same strength), sparks first passed at an interval of 96 mm. When the point was removed further from the plate there appeared only radiations. The sparks which appeared at 96 mm. interval were zigzag in form, thin, and without much sound, and they continued so till the interval was contracted to 56 mm. Then the spark altered in its nature—it became pretty straight, and produced a more intense sound.

The peculiar aspect of the spark between 96 mm. and 56 mm. interval suggested the idea that positive electricity was carried over, and the insertion of a Holtz funnel tube confirmed this fully. By other means, and directly with the electrometer, it was demonstrated that with an interval between the point and the plate of from 96 mm. to 56 mm., there passed from the point which was negative at the break of the primary current positive electricity, whereas with a less interval of spark, negative electricity passed.

For this interesting phenomenon, which the author intends to study further in its details, he offers the following explanation:

The opening of the circuit of the primary coil at first brings to the point at the so-called negative pole negative electricity. If, now, the

distance of this point from the opposite plate be greater than 96 mm., the negative electricity cannot pass in sparks; but, also, the oscillation which immediately thereon occurs in the induction wire, and which now brings positive electricity to the previously negative point, has not power enough to discharge this positive electricity in sparks, because the tension produced by this backward oscillation (Rückschwingung) is weaker than that produced by the first direct impulse at break of the primary, this being capable of breaking through an interval of 240 mm. When the point at the negative pole is approximated to a distance of 96 mm. to 56 mm. from the plate, still the negative electricity driven to the point by the break of the primary circuit cannot pass over in sparks; but the positive which thereupon comes to the point in the oscillation which then occurs, can do so. Since, however (as already remarked), the tension produced by it is less than that produced through the direct action from the break, the spark is thinner and less powerful than if, with the same interval, the point be made the positive pole by reversing the direction of the primary current. If the negative point be now brought nearer to the plate, to a distance less than 56 mm., the negative electricity brought to it by the break of the primary current can pass in sparks. But by this discharge the following oscillation is so weakened that it does not render luminous the corresponding funnel tube, or does so to a very slight extent.—*English Mechanic.*

THE SUN'S POWER.

In an interesting and eloquent paper on "The Sun a Source of Power," published in the *Scientific American*, Prof. Langley takes the following method of giving some idea of the work performed by the sun's heat on our earth, which receives only a small fraction of the enormous quantity sent out yearly from the centre of our system. Assuming the area of Manhattan Island to be 20 miles and the annual rain-fall 30 inches, he shows by a simple calculation that this small portion of the earth receives 1,393,920,000 cubic feet, or 38,781,600 tons, of rain in a year. "The amount of this," he says, "may be better appreciated by comparison. Thus, the Pyramid of Cheops contains less than 100,000,000 cubic feet and weighs less than 7,000,000 tons; and this water, then, in the form of ice, would many times replace the largest pyramid of Egypt. If we had to cart it away, it would require 3,281,800 cars

carrying 12 tons each to remove it, and these, at an average length of thirty feet to the car, would make six trains, each reaching in one continuous line of cars across the continent, so that the leading locomotive of each train would be at San Francisco before the rear car had left New York." A day's rain-fall of one-tenth of an inch spread over the United States represents ten thousand millions of tons, and would take, he states, more than all the pumping-engines which supply Philadelphia, Chicago, and other large cities dependent more or less on steam for potable water, working day and night for a century, to put it back to the height to which it was raised by the sun before it fell. It has been found by careful experiment that the effect of the heat of a vertical sun in the month of March, acting on a square foot of the earth's surface, after having lost a portion of its energy through absorption by our atmosphere, is equivalent to 0·131 horse-power, and other problems with equally startling results can be readily framed from this and other accessible data.

In "Progress" we find the following short sermon on the power of God evinced in a recent storm: "We have had four to six inches of rainfall in Philadelphia, and perhaps over the whole area of several States. Let us measure in barrels or tons this vast avalanche, and calculate the amount thus beneficently dispersed. A square foot, covered one inch deep with rain, would, of course, represent one hundred and forty-four cubic inches of water. Now, as one pint contains about twenty-eight cubic inches, one square foot one inch deep contains say five pints. Therefore an acre, covered one inch deep, would need twenty-seven thousand gallons, weighing eight pounds each, or over one hundred tons of water per acre for every one inch of rainfall; sixty-four thousand tons for every square mile; eight million tons for the area of Philadelphia. The silent force of the sun has lifted this enormous aggregate a distance of say one mile high; has carried it suspended in the atmosphere perhaps a thousand miles, and then has precipitated it as the gentle dew, the dashing shower or the thundering rainstorm. Such and so vast are the powers of Nature."

Phosphatic Beds.—Geological explorations have shown the probability that Russia contains beds of phosphate of lime of sufficient extent to supply Europe for an indefinite period. Three companies have already begun to work the deposits.—*Fortsch. d. Zeit.* C.

COHNE'S ELECTRIC CANDLES.

An improved form of electric candle has been patented by Mr. S. Cohné of 65 Grace-church street, London, for which the following advantages are claimed:

Up to the present time all electric candles in use have been made from pure carbon or carbon mixed with other substances, such, for example, as kaolin or plaster of Paris, all which have the great disadvantage of burning too quickly away and producing, in a greater or lesser degree, a flickering light. Such candles therefore require controlling mechanism to regulate their distance from each other. Mr. Cohné's invention consists in making or forming a candle of ultramarine or the substances which when united together form or produce ultramarine. The ultramarine may be green, blue or of any other color in which it is produced. It may be used either in its pure state or mixed with carbon, kaolin, plaster of Paris, molasses, or with any metal reduced to powder so as to be in a finely divided state. The metal preferred is copper, and it is ultramarine, carbon, powdered copper and molasses that the patentee employs. To about four parts of carbon he adds one part of ultramarine and one part of the finely divided metal and as much molasses as will when mixed with the other materials be sufficient to form the whole into a paste which can be moulded or otherwise formed into the shape desired. The candle thus formed is dried and heated for a sufficient time by fire by whose action all the moisture is evaporated, the sulphur is burned away, and the molasses as well as all other organic matter becomes carbonized. The patentee does not confine himself to the exact proportions named above, and it will be understood that the mixture alluded to is only one of those in which the candle may be made. When these candles are put into use the resistance and the current in the arc are to a very great extent less varying, and controlling mechanism to regulate the distance is nearly unnecessary, because the candle is consumed very slowly in comparison to those heretofore in use. Moreover, less consumption of energy is required for the new candle, and therefore the divisibility of the electric light becomes easier. For effecting the latter purpose, Mr. Cohné bakes the candle in a zinc tube, whereby the zinc of the tube sublimates, and partly enters into the candle. By this means the conductibility is greatly increased; thus very little consumption of energy takes place, and the problem of the divisibility of the electric light approaches solution.—*English Mechanic.*

DIVISIBLE CANNON.

Translated for the JOURNAL.

The Russian artillery have lately adopted a style of cannon entirely new, destined to play an important part in future wars.

This cannon has the peculiarity that it can be divided into two, three or four parts, which may be transported separately, to be united at any place. The moving of it may be very rapid, and the mechanical means employed to maintain the parts in contact assure the perfect solidity of the cannon. We see immediately what services this new system applied to cannon is called upon to render in wars in mountainous countries. Difficulties often insurmountable in the transport of heavy artillery through gorges more or less abrupt have evidently been overcome by this possibility of dividing the total weight of the cannon in a number of parts relatively much lighter. The Russian government, struck with these advantages, wished, on the occasion of the late war in the Balkans, to make a trial of the new engine. The first experiments were made in Russia with a gun of small size, and the results were so satisfactory that the War Department undertook without delay the construction of a divisible cannon of twenty centimetres interior diameter and of a mortar, equally divisible, of twenty-three centimetres. The cannon of twenty centimetres is in four pieces: 1. An interior tube of a weight of 541 kilogrammes; 2. the breach, weighing 2904 kilogrammes; 3. the chase (part of the cannon comprised between the trunnions and the mouth), of a weight of 1826 kilogrammes; 4. The trunnions, weighing 98 kilogrammes. This would make a weight of 5369 kilogrammes in the entire cannon mounted. This piece has served, in company with a similar mortar, in the late Turco-Russian war.

The trials have been so decisive that the government of St. Petersburg has already constructed pieces of even a larger calibre upon the same principle of division.—*Le Propagateur.*

Artificial Asphalt.—V. L. Dagusan heats coal- or wood-tar in a boiler until the water is all evaporated, adds finely powdered marble or limestone that has been previously burnt, stirring in 5 per cent. of iron oxide, silicate of potash, and gypsum, and mixing the whole thoroughly.—*Dingler's Journal.* C.

Portable Gas.—In England portable gas is now sold and delivered like milk. Country residents receive it from the city in copper cylinders.—*Fortsch. d. Zeit.* C.

Krupp's Homogenous Iron.—After a long series of successful experiments Krupp has placed his "Fluss-Eisen" upon the market as a substitute for malleable iron. With a content of about one-tenth of one per cent. of carbon it resembles the best forged iron, but is superior to it. In large forged pieces it has a resistance of from 38 to 42 kilogrammes per square millimetre (54,046·7 to 59,735·8 lbs. per square inch). In sheet iron the tenacity is raised to between 40 and 48 kilogrammes (56,891·3 to 68,269·5 lbs. per square inch), with an elongation of about 25 per cent. and a diminution of 50 per cent. in the section of the experimental bar at the moment of rupture. The price is little higher than that of ordinary iron. The material is specially valuable for shafts, stern-posts, anchors, machinery, and all work which requires welding when it is made of common iron.—*Ann. du Génie Civil.* C.

Courtenay Automatic Whistling Buoys.—After a thorough trial of these buoys in two of the French light-houses, the Ministry purchased them and ordered eight more, on the recommendation of the Light-house Board. The Chamber of Commerce, the pilots and captains who were consulted, all agreed that they were of great service. The only objections that were made to their purchase came from villagers who were annoyed by the noise, and they were conciliated by removing the buoys to a greater distance. The liabilities to wear or damage are very small; the mechanism is remarkably simple; the ball-valves can work for years without need of repairs. The whistle may be injured by collision; this accident has already occurred at Havre, where the channel is furrowed, at all hours of the day and night, by the numerous fishermen who are careless sailors. To guard against a recurrence of this injury the inventor has devised a protective gallery. Wind, ground-swell and moisture, all increase the penetrating power of the whistle, provided they are not excessive. This is probably owing to the increased compression of the air in the sounding chamber. The intervals between the whistles can be graduated as easily as the flashes of revolving lights, so that the different signals cause no confusion when a number of buoys are anchored in the same neighborhood.—*Ann. des Ponts et Chauss.* C.

The Camphor Eddies.—If a small bit of camphor is laid upon water it begins turning and moving about with great rapidity. If a few grains of lycopodium or other light powder have been previously scattered on the water they are drawn towards the camphor by eddies in an inverse direction. These phenomena were observed in 1748 by Romien, who attributed them to a difference of electricity between the water and the camphor. Subsequent investigators thought they might be due to the camphor vapor striking the water and producing a recoil. M. Cassamajor has resumed the study of the questien and adopted the views of Romieu. He instances the following crucial experiment. At the same time that the bits of camphor are thrown upon the water insert a glass rod which has been rubbed with flannel: the motion immediately stops. If the electricity is removed from the rod by rubbing it with tin foil, it loses its power of checking the eddies.—*Les Mondes.*

C.

Saharan Railway.—M. Duponchel proposes the construction of a railway across the desert of Sahara, the first section extending from Algiers to Timbuctoo. Soudan, watered by large rivers, bathed by great interior lakes, shaded by magnificent trees, might produce, in unlimited quantities, rice, grain, sugar cane, cotton, indigo, etc. The project of attaching this fertile region to Algeria, Marseilles and France would be more easily carried out than the Pacific Railroad, which was completed in three years, over declivities 1800 metres (1·1185 miles) high, with immense defensive works, among which are the wooden tunnels which have an aggregate length of not less than 70 kilometres (43·497 miles). The entire route was 3080 kilometres (1913·8 miles), which was somewhat longer than the proposed route, but the difficulties were, perhaps, no greater. The Sahara has a hard, tough soil, and the sand dunes, which are often supposed to cover the whole surface, would not occupy more than a ninth part of it. The dunes may be owing to the disintegration of rocks, under a long-continued solar action, and the distribution of the debris, by the fierce winds of the desert, into scattered hills. Wherever there is a liability for such shifting, it would be necessary to protect the road by wooden sheds, like those on the Pacific Railway.—*Bull. de la Soc. d'Encour.*

C.

Glass Lamp-wicks.—Lamp-wicks of spun glass are made in Germany. They supply the petroleum, oil or spirit more regularly, and lamps which are provided with them can be carried about with less danger of going out or of scattering sparks and kindling conflagrations. For equal strength of flame the glass wicks give a clearer and purer light; they have a less unpleasant odor; they consume less fuel; in spirit-lamps they give a more intense heat, with a more quiet and steady flame.—*Fortsch. der Zeit.* C.

New Application of Hydrogen.—E. Commelin has discovered a new industrial application of hydrogen. He places retorts or tubes of metal or refractory earthen-ware in the arch of furnaces or generators, in hot-air apparatus or elsewhere, where they are exposed to a red heat. They are filled with charcoal, coke or cinders, and a small jet of vapor is introduced, which produces, by decomposition and recomposition, hydrogen, carbonic oxide and carbonic acid. The apparatus is thus raised to a red heat and steam is obtained without expense. Each tube which contains 25 kilos (55 lbs.) of coke yields, in 10 hours, 100 cubic metres (3531·658 cubic feet) of gas, which is passed into a purifier and thence to a gasometer. Its illuminating power is increased by mixture with the vapor or gas of volatile or solid hydro-carbons, so as to yield, at about one-sixteenth the cost, a whiter and more brilliant flame than that of coal gas.—*La Houille.* C.

Blood of the Lobster.—Harless found copper in the blood of crustaceans, cephalopods and gasteropods. It has long been known that the blood of these three groups of invertebrates changes its color when it is exposed to the air. Jolyet and Regnard concluded that the blood of the crab contains two coloring substances, one blue and the other red. The first is united with the albumen, which, when coagulated by alcohol, has a clear blue tint; the red dye remains in solution in the alcoholic filtrate. Léon Fredericq finds the same principles in the blood of the lobster, but the red contains no metal; it does not change color in oxygen or in a vacuum; it is not always present. The blue seems to be identical with hemocyanine and contains copper. The saline portion of the blood has a composition almost identical with that of the water in which the lobster lives. The hemocyanine easily unites and parts with oxygen and thus acts as a stimulant to respiration, the nutritive function of the blood being confined to the plasma. —*Bull. de l'Acad. Roy. de Belgique.* C.

Incombustible and Impermeable Wood.—M. Folbacci uses the following preparation: Sulphate of zinc, 55 lbs.; potash, 22 lbs.; alum, 44 lbs.; oxide of manganese, 22 lbs.; sulphuric acid of 60°, 22 lbs.; water, 55 lbs. All the solid ingredients are put into a boiler containing the water at 45°C. (113°F.), and as soon as they are dissolved the sulphuric acid is poured in gradually until the mass is completely saturated. The pieces of wood are kept about 5 centimetres (1·97 in.) apart, and after three hours' boiling they are dried in the open air. The natural appearance of the wood is not changed; to whatever heat it is subjected, it resists combustion, the surface being simply covered with a thin charred coating which is easily rubbed off. —*Ann. du Génie Civil.* C.

Water-spouts at Vitry-sur-Seine.—L. V. Meunier describes two simultaneous water-spouts, one of which was very long and slender, resembling a cylindrical ribbon and assuming a kind of S shape. M. Faye institutes a comparison between them and similar phenomena which were observed in China, in July, 1878, and gives the following explanation, in accordance with his theory. The air which is brought down by the water-spout is usually colder than the lower strata. When the reduction of temperature passes the dew-point of the surrounding air the spout is surrounded by a light cloud which marks its contour. If, in moving, it penetrates layers which are cooler or drier, this vaporous sheath is dissipated; but the cold column still exists, and continues to lash the water or the ground by its lower invisible extremity, so as to form a cloud of drops of water or of dust. At last, when the descending spires, centered upon a vertical axis, are displaced horizontally by the feeble winds prevailing at different heights, the vaporous envelope undulates more or less violently. As the spires have not all the same radius, nor the same temperature, and as they even form distinct helicoidal currents around a common axis, it may happen that only the central spires are cold enough to precipitate the moisture and form a sheath which is much smaller than the entire channel of the whirlwind. [The S form of the vertical column may be due to simultaneous cyclonic and anti-cyclonic influences, like the similar horizontal formation of synchronous anti-cyclonic snow-storms and cyclonic rains which are so often shown upon the weather maps of the United States Signal Service.]—*Comptes Rendus.* C.

New Antiseptic.—A new and very valuable antiseptic has been discovered in Germany. It is a double salt of borate of potassium and sodium, and is made by dissolving in water equal portions chloride of potassium, nitrate of sodium and boracic acid, filtering and evaporating to dryness. It costs about twenty-five cents a pound, and does not give bad taste and properties to foods. Butter may be made from milk kept sweet by it at ordinary temperature for a week. Meat, game, etc., dipped in a weak solution, remain pure for a long time. A piece of meat well rubbed with the salt and laid away two years ago is now in perfectly good condition. Eggs are dipped in a solution; beer and wine are placed in bottles previously rinsed by it, and remain good for long periods.—*Journal of Chemistry.*

Book Notices.

ELEMENTS OF NATURAL PHILOSOPHY. For the use of Schools and Academies. By Edwin J. Houston, A.M., Prof. Physical Geography and Natural Philosophy, Central High School of Philadelphia, etc. Philadelphia: Eldredge & Bro. 1879.

An elementary work of this nature demands as its chief passport to favor that its arrangement shall be logical, and that its presentation of the facts and principles of the science shall be correct, concise, attractive, and free from ambiguity; but these requirements are so seldom fulfilled that while admirable works of a higher class, adapted to the needs of advanced students, are plentiful, the number of really first-class elementary text-books for beginners has always been limited. The reasons for this are not difficult to assign, and they are to be found partly in the disinclination of capable scientific teachers and investigators to descend from the higher regions of the lecture room and laboratory to place themselves *en rapport* with the childish mind, and partly in the real difficulty of its proper accomplishment, for to do it well demands the exercise of a happy faculty which few possess.

In this particular field the author's previous essays have been attended with an unusual share of success. His "Elements of Natural Philosophy," with which we are here especially concerned, has been written in his happiest vein, and it is almost enough to say of it, for the private ear of the teaching fraternity, that it is qulte as deserv-

ing of commendation as his "Elements of Physical Geography," which the writer of this had the gratification of commending before it had reached its present measure of popularity.

In the present book the subjects are presented in logical sequence, and while nothing essential has been omitted itr size has been confined within convenient limits. The author's language is clear and concise; the examples by which the principles and facts of the science are elucidated are well chosen, and many of the experiments suggested for for the same purpose are simple and homely and on thsse accounts especially valuble in impressing proper conceptions correctly and intelligently upon the beginner's mind.

While all the sub-divisions of the science are well represented that of electricity is deserving of especial notice, from the fact that the author in relegating magnetism to its proper subordinate place as one of the effects of the electrical current, and in treating the subject generally under the divisions "electrical charge" and "current electricity" has greatly simplified it and brought it more closely in harmony with the present state of our knowledge. The final chapter covers briefly the late advances that have hoen made in this field of investigation, including therein descriptions of the theory and action of galvano-electric machines, telephone, microphone and phonograph.

The publishers, too, have done their part well, and the paper, letter-press and illustrations are very creditable. W.

RECREATIONS IN ASTRONOMY, With Directions for Practical Experiments and Telescopic Work. By Henry White Warren, D. D., Author of "Sights and Insights; or, Knowledge by Travel," etc. With eighty-three illustrations and maps of stars. 12mo. New York: Harper & Brothers. 1879.

Dr. Warren is well known to many of our readers as a ready and pleasing writer, full of generous enthusiasm for the harmonies of scientific and religious truth, and an amateur astronomer, whose familiar knowledge of the heavenly bodies has often been instructively imparted to circles of admiring listeners. His own extensive reading has been supplemented by assistance from others, for which he especially acknowledges his indebtedness to Professors J. M. Van Vleck, LL.D., Henry Draper, M.D., and Simon Newcomb, LL.D., and to Dr. S. S. White. Great care is manifested, in all parts of the work, to present the latest information in a simple yet picturesque style, with scrupulous

accuracy, and with such judicious avoidance of needless technical explanations as will bring the subject fully within the grasp of ordinary readers. With the belief, strengthened by an experience which entitles it to great weight, that

"——— the undevout astronomer is mad,"

he has written a book of unusual interest, "not only to unravel some of the highest achievements of the human mind, but also to let the heavens declare the glory of the Divine Mind." Its value is greatly enhanced by beautiful illustrations and admirable typography. C.

ELEMENTS OF MODDRN CHEMISTRY. By Adolph Wurtz, Member of the Institute, Honorary Dean and Professor of Chemistry of the faculty of Medicine of Paris, etc., etc. Translated and edited from the fourth French edition by Wm. H. Greene, M.D., formerly Demonstrator of Chemistry in Jefferson Medical College, Philadelphia, etc., etc. 12mo, pp. 687, with 132 illustrations. Philadelphia: J. B. Lippincott & Co.

While manuals of chemistry have not been wanting in number, this book will supply a want which has long been felt by teachers and students, who have had no choice between small and imperfect text-books and volumes whose magnitude is entirely beyond the time that can be allotted to chemistry.

The author introduces the translator as his "friend and former pupil," and expresses confidence that the translation will be "a faithful or even improved representation of the original work."

The opening chapter treats of the evident differences in the forms of matter, and clearly defines those differences which it is the province of chemistry to investigate. The laws of definite proportions and equivalents are then explained and naturally developed into the atomic theory, which is sustained by a terse statement and explanation of Gay-Lussac's law and the laws of specific heat and isomorphism.

A short but lucid chapter on nomenclature and notation follows, after which the metalloids are taken up individually and arranged in classes according to their chemical analyses, the only basis for a rational classification.

After the student has become familiar with the compounds of the metalloids he is initiated into the probable laws of affinity by the study of the theory of atomicity, which most important doctrine is here stated more clearly than in any other book we have seen.

The history of metals individually is preceded by a description of their general properties, an interesting article on alloys and a general consideration of oxides, hydrates, sulphides, chlorides and oxygen salts, each group being individually considered and important characteristics pointed out.

Nearly half of the book is devoted to organic chemistry, and all of the preliminary explanations are condensed into thirty pages; besides these we find pages here and there devoted to the general molecular structure of the amines, organo-metallic compounds, series of fatty acids, glycols, etc., this matter being introduced when the student is fully prepared for it, so that he may not be obliged first to study general formulæ for classes of bodies of which he knows nothing.

The book is fully up to the times and is an exact representation of the science, all facts being viewed in the light of the most recent developments. It is clearly written, and will be welcomed not only by students and teachers but by chemists and others, who have felt the want of such a book.

The paper, press-work and typography is excellent, as might be expected from Lippincott's house.

Franklin Institute.

HALL OF THE INSTITUTE, Sept. 17th, 1879.

The stated meeting was called to order at 8 o'clock P. M., the President, Mr. William P. Tatham, in the chair.

There were present 112 members and 59 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and announced that at the last meeting seven persons were elected members of the Institute; and reported also the following donations to the Library:

Specifications. No. 2043, of 1795; No. 53, of 1878.
From the Commissioners of Patents, London, through Mr. Frederick Ransome.

The Pennsylvania Railroad; its Organization, Construction and Management. By James Dredge. London, 1879.
From Frank Thomson, Gen'l Manager Penna. R. R.

Annual Report of the American Institute of New York.
From the Librarian.

Transactions of the American Society of Civil Engineers. No. 53.
From the Society.

Ninth and Tenth Reports of Exhibitions of the Massachusetts Charitable Mechanic Association. From the Association.

American Naturalist. 4 Nos.
From the Boston Medical Association.

Boston Journal of Chemistry. 7 Nos. From the Publishers.

American Architect and Building News. Vols. 1 and 2.
From J. R. Osgood & Co., Publishers.

Quarterly Report of the Chief of the Bureau of Statistics.
From the Chief of Bureau.

Annual Report of the Trustees of the Metropolitan Museum of Art. From the Association.

Circulars of Information of the Bureau of Education. No. 2.
From the Bureau.

Report on a Preliminary Investigation of the Properties of the Copper-tin Alloys. From R. H. Thurston.

Annual Report of the Commissioner of Patents, with Index for 1878.
Specifications and Drawings of Patents for March and April, 1879.
From the Patent Office.

Report of the Board of Health of the City and Port of Philadelphia to the Mayor. From Geo. E. Chambers, Registrar.

Papers read before the Eleventh and Twelfth Annual Conventions of the American Institute of Architects, held in Boston and New York. From A. Williams & Co., Publishers.

General Index of the Agricultural Reports of the Patent Office, for twenty-five years, from 1837 to 1861; and of the Department of Agriculture for fifteen years, from 1862 to 1876. Washington, 1879.
From the Commissioner of Agriculture.

Silk Goods of America: A Brief Account of the Recent Improvements and Advances of Silk Manufacture in the United States. By W. C. Wyckoff. From Horstmann & Co., Philadelphia.

Sheet Metal Builder. An illustrated Monthly devoted to the use of Sheet Metal in Architecture. Vols. 1 and 2.
From Dr. W. H. Wahl.

Charter, By-Laws, Regulations and List of Members of the Institution of Civil Engineers. London. From the Institution.

List of Premiums of the Twenty-sixth Annual Exhibition of the Pennsylvania State Agricultural Society. From the Society.

Annual Report of the Managers of the State Lunatic Asylum, Utica, N. Y. From the Managers.

Report of the Board of Experts on the Test Trial of the Warden Compound Pumping Engine to the Board of City Commissioners of Cincinnati Water Works, March 1879. From J. W. Hill.

Contributions to our Knowledge of the Meteorology of the Arctic Regions. Part 1.
From the Meteorological Committee of the Royal Society.

Annual Report of the Chief of the Water Department of the City of Philadelphia. From W. H. McFadden, Chief Engineer.

Annual Report of the Chief Signal Officer to the Secretary of War.
From the Chief Signal Officer.

Fourth Annual Report of the State Board of Health of Massachusetts. From Dr. Bringham, Boston, Mass.

Official Army Register. From the Secretary of War.

On Magnets. By O. A. L. Pihl. Christiania.

Die Lehre des Ammonius Sakkas. Von Dr. G. V. Lyng.

Om Forholdet i Middlelalderen Mellem den Norske Mark, solv og den Stedse Forringede Gangbare Myntmark, etc. Af C. J. Schive.

Philosophische Studien Von Dr. G. Wilh. Lyng.

Lettre à M. Ernest de Sauley.

Om Advokat Sandons Affære. Af O. Sandberg.

Bemærkninger om Tilregnelighed (Strafskyld) og Sindssygdom, etc. Af Prof. Dr. Faye.

Nogle Oplysningen om Forholdet mellem Ægteskaber og Fodsler med særligt Kensyn til Ægteskabernes Sliftelsestid. Af Bureauchef Kiær.

Om Poncelet's Betydning for Geometrien, etc. Af Elling Holst.

Carte du Royaue de Norvège.

Carte Norge, Sverige og Danmark.

Rume-Indskriften paa Ringen i Forsa Kirke i Nordre Helsingland. Udgivet og tolket af Sophus Bugge.

Om Skuringsmærker, Glacialformationen og Terrasser, samt om Grundfjeldets og Sparagmitfjeldets Mægtighed i Norge. 1. Grundfjeldet. Af Prof. Theodor Kjerulf. 2. Sparagmitfjeldet.

Om Stratifikationens Spor. Af Dr. Theodor Kjerulf,

I Anledning af Schopenhauers af det Throndhjeinske Fidenskabersselskab belonnede Prïes. Afhandling om den Frie Villies Forhold til Selvlevidstheden. Af M. J. Monrad.
From the University of Christiania.

Dr. Robert Grimshaw read a paper on "Cork Utilization," which was discussed by Messrs. Nystrom and Orr.

Mr. Carbutt read a paper on Heliography, and made some practical remarks on the process, at the same time exhibiting a number of beautiful specimens of the work and its varied application in the arts.

The Secretary read a paper giving an account, as far as has been made known to the public, of the "Autoplate" of Louis Brown & Co., and a number of specimens of the work were exhibited, also some large "Photo-gravures" of Goupil & Co., supposed to be made in a a similar manner to the Autoplate, and kindly loaned for the occasion by Messrs. Earle & Son.

Mr. Joseph J. Walton exhibited Queen's new form of Tisley's Compound Pendulum for the first time to a public audience in Philadelphia, and a number of beautiful curves, corresponding to sonorous vibrations, so well known under the name of Lissajous' figures, were thrown upon the screen.

The Secretary's report included accounts of Dickson's process of engraving blocks in hard rubber; Barthelet's Duplicator for producing a number of copies of any writing, drawing or music; the Columbia Bicycle, as manufactured by the Pope Manufacturing Co., with the Cyclometer for indicating the distance traveled; also the Lantern, Alarm Bell, Saddle Bag, etc.; Portable Wash-stands, giving an instantaneous flow of water without connections with the city supply; Nichol's Acid Syphon Pumps; Cooper's plan for reference books; Denison's Patent Reference Index; Lever's method for wire-sewing books; Hoyt's Indestructible Binding; Ferree's Binder for magazines, pamphlets, etc.; Creswell's Double-hinged Open Link; R. & J. Beck's Economic Microscopes, monocular and binocular; Godley's Patent Improved Loose Wheel for Railroad Cars; Pohl's Adjustable Metallic Awning; Nystrom's Metallic Thermometer for ascertaining the temperature of steam; Schutte & Goehring's Water Jet Vacuum Pump for laboratory use; I. Newton Peirce's Patent Portable Boiler Covering; Rebounding lock principle, as applied to the Smith and Wesson Revolver, and an exhibit of the various products of the Health Food Company of New York.

Mr. John W. Nystrom read a paper upon the cause of steam boiler explosions, and illustrated it by drawings on the blackboard.

On motion, the meeting adjourned.

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